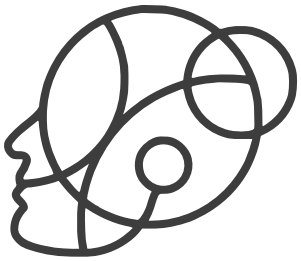

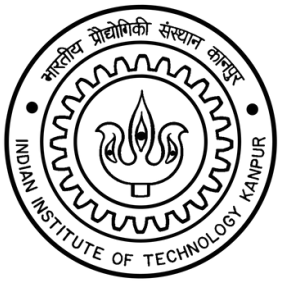


## 10th Annual Conference of Cognitive Science


9th to 11th December, 2023

# PROGRAM BOOK

DAY 1

9th December, Saturday

# PROGRAM SCHEDULE

| TIME | EVENT |
|---|---|
| 8:30 - 9:30 | Registration |
| 9:30 - 10:00 | Opening Ceremony |
| **10:00 - 10:45** | **Keynote 1: Marc Brysbaert** |
| 10:45 - 11:00 | Coffee break |
| 11:00 - 12:00 | Talk Session 1: Attention and Perception |
| 12:00 - 1:00 | Poster Session 1 |
| 1:00 - 2:00 | Lunch |
| 2:15 - 3:00 | Talk Session 2: Learning and Memory |
| **3:00 - 3:45** | **Cognitive Science in India - Past, Present & Future** |
| 3:45 - 4:00 | Coffee break |
| 4:00 - 5:15 | Talk Session 3: Language |
| 5:15 - 5:45 | Sponsor’s Session |
| 5:45 - 6:15 | ACS General Body Meeting |

DAY 2

10th December, Sunday

# PROGRAM SCHEDULE

| TIME | EVENT |
|---|---|
| 9:30 - 10:30 | Talk Session 4: Emotion and Cognition |
| **10:30 - 11:15** | **Keynote 2: Mark Elliot** |
| 11:15 - 11:30 | Coffee break |
| 11:30 - 12:30 | Poster Session 2 |
| 12:30 - 2:00 | Lunch |
| 2:00 - 3:00 | Talk Session 5: Cognitive Disorders |
| **3:00 - 3:45** | **Keynote 3: Sridharan Devarajan** |
| 3:45 - 4:00 | Coffee break |
| 4:00 - 5:00 | Talk Session 6: Disorder Intervention |
| 5:00 - 6:00 | Poster Session 3 |
| 8:00 onwards | Gala Dinner |

DAY 3

11th December, Monday

# PROGRAM SCHEDULE

| TIME | EVENT |
|---|---|
| 9:30 - 10:15 | Talk Session 7: Cognitive Control |
| **10:15 - 11:00** | **Keynote 4: Anindita Bhadra** |
| 11:00 - 11:15 | Coffee break |
| 11:15 - 12:00 | Talk Session 8: Social Cognition |
| 12:00 - 1:00 | Poster Session 4 |
| 1:00 - 2:00 | Lunch |
| 2:00 - 2:45 | Talk Session 9: Creativity and Aesthetics |
| 2:45 - 3:00 | Valedictory and Award Ceremony |


DEPARTMENT OF COGNITIVE SCIENCE
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# KEYNOTE ABSTRACTS

**Keynote Session 1**

## The limits of Popperian research: What psychology researchers must learn from engineers

Marc Brysbaert
*Ghent University, Belgium*

Research in psychology is dominated by Popper's approach, in which absolute priority is given to test new, bold hypotheses. Existing knowledge is not trusted and there is little room for efforts to understand and solve existing problems in a constructive, incremental and collaborative way. Detailed descriptions of problems, fine-grained investigations of relationships among variables and incremental improvements to existing measurements are of secondary importance and are not rewarded in the grant and publication system. It is argued that this situation has arisen from an overzealous interpretation of the recommendations of philosophers of science on how to do good research, just as behaviorism was an overreaction to the guidelines given at the beginning of the 20th century on the scientific method. Ward (1998) already warned that the Popperian approach leads to far less progress in understanding real, complex problems than an engineering approach in which researchers first try to understand the problems, then try to develop tools that improve performance, and only apply falsification when they have a good understanding of the problem. Developments in the 21st century have confirmed Ward's warnings (see also Scheel et al., 2021). In this talk, I will show how psycholinguistic research is adopting Ward's recommendations, how this has interacted with the big data approach, and how other areas of research are likely to benefit from the approach.

# KEYNOTE ABSTRACTS

**Keynote Session 2**

## The Temporal, Spatial and Figurative Structure of Visual Apperceptive Space

Mark Eliott
*School of Psychology at University of Galway*

Our understanding of human visual perception generally rests on the assumption that a conscious visual state represents, as some qualitative product, a complex interaction between spatially structured variations in the ambient optic array and our visual nervous systems. The existence of visual hallucination (purely subjective experience or 'Apperception' as this refer to Herbart's 'Vorstellungen') in a number of pathologies as well as in experimental contexts questions the assumption that what we see in the environment is necessarily determined by spatial structure in the distal stimulus. It also indicates that conscious visual states might be triggered by external stimulation that does not ultimately relate to what the observer actually 'sees' in the environment. We have shown that the apperception of complex colour and forms is evoked by flickering light and that the type of apperceptive experience can vary with flicker frequency and phase. The occurrence of a given apperceptive experience is also determined by its co-occurrence with other experiences. These results indicate that experience of colour and form may be evoked directly by particular variations in the flow of spatially unstructured light over time even though this visual stimulus is not characterized by any particular colour or form: This evidence supports theories of apperceptive, or experiential structure related to the dynamic constraints applied by the underlying brain-cognitive system.

# KEYNOTE ABSTRACTS

**Keynote Session 3**

## Splitting attention into its atomic components

Sridharan Devarajan
*Centre of Neuroscience, IISc Bangalore*

Every day, we face an information overload. How does our brain select information that is relevant for behavior and ignore that which is irrelevant? This is the central question driving our research: to understand the neural basis of the cognitive capacity that we call, and intuitively understand as, "selective attention". Surprisingly, despite more than a century of research, neuroscientists, psychologists and philosophers alike continue to grapple with very fundamental aspects of attention, like its definition and even its very existence! I will argue that this is perhaps because attention is not an atomic (unitary) phenomenon. Recent experiments from our lab confirm that attention can affect behavior through at least one of two sub-components. One enhances "sensitivity" by improving the sensory processing of relevant information. The other enhances "bias" by prioritizing the most relevant information for making decisions. I will describe several lines of experiments from our lab that leverage diverse techniques, including psychophysics, neurostimulation, diffusion MRI, MR spectroscopy, EEG, and modeling, that enable us to split attention into its atomic components. The results may "shatter your worldview" of this ubiquitous cognitive phenomenon!

# KEYNOTE ABSTRACTS

**Keynote Session 4**

**Dogs and their human neighbours in the Urban Ecosystem**

Anindita Bhadra
*Department of Biological Sciences, IISER, Kolkata*

Dogs and humans share a very special relationship, which has evolved at least 15000 years ago. Pet dogs are known to understand various human social gestures and postures, and show a high degree of reliability on humans. They are also totally dependent on their human owners and caregivers and are raised in human homes, which is likely to influence their cognitive abilities and personalities. Free-ranging dogs present an interesting model system for understanding the innate nature of dogs, and their abilities to communicate and interact with humans without prior training. This talk will highlight some of the findings of The Dog Lab that help us to understand dogs and their ability to survive in the human jungle.

# ORAL PRESENTATION ABSTRACTS

## Talk Session 1: Attention and Perception

### Inverting a continuous flash suppression task to measure temporal regularities of devolution of visual content

Singhal, Ishan*; Srinivasan, Narayanan
*Department of Cognitive Science, IIT Kanpur*

Continuous flash suppression (CFS) has been a useful tool in consciousness studies for the last two decades. This particular experimental setup requires that different inputs be present to each eye, similar to binocular rivalry. A target image is presented to one eye and the other is presented with a flickering mondrian mask. When participants view pictures in a CFS setup, they perceive the two inputs as fused and overlapping. The flickering mask suppresses the target from immediately entering into awareness, even though the target remains completely visible. Investigations of the mechanisms behind this suppression have revealed the flicker-frequency of the mask to be important. Several studies have reported that slow flicker rates (3-7 Hz) lead to longer suppression durations compared to faster flicker rates (10-25 Hz). All of these studies have used breakthrough times, which is a measure of how long it takes for a stimulus to become visible. Here, we created an opposite task. We tried to measure how long it takes for a target image to disappear from awareness as a function of the flicker-frequency of the CFS mask. We hypothesized that the disappearance time would be maximum at very slow frequencies compared to faster flickering rates. This hypothesis allows us to test several tenets of awareness. One, that if breakthrough times are longer at slower frequencies, the same should apply to disappearance times. Hinting at the fact that slower flicker rates modulate not just entry into awareness but also maintenance of content. Though, whether visual content enters and devolves from awareness symmetrically in time is an open question, one that we attempt to address here. Second, conceptualizations of psychological present moments (“nows”) have postulated that experienced content is retained over a few seconds. This paradigm allows to test how this present moment of content retention is modulated as a function of flicker frequency.

For the experiment, we recruited 12 participants (4 females, mean age = 25.6 years). The sample size was calculated by conservatively halving previous effect sizes and calculating a sample size required for a power of 0.85. The participants were shown a picture of a face as a target image. This image was presented alongside a flickering mask with four possible flicker rates (1, 4, 10 and 25 Hz). Generally, in CFS paradigms, the targets are presented at low contrast and ramped over time to allow for maximum suppression. Since we had reversed the task to disappearance rather than appearance, we reversed this ramp. The image of the face was presented at maximum contrast when the trial started (60%) such that participants clearly see the face at the start of the trial. This image was then ramped down in contrast (10% per second) over the duration of a trial. Participants were told to report the transition from seeing a face to not seeing a face. They were told to respond as fast as possible. Each participant ran a total of 120 trials. Out of these 96 were main trials (24 trials per flicker frequency) and 24 were catch trials. On catch trials, the image of the face did not ramp down and it did not disappear from the screen. These trials were used to ensure that participants were not arbitrarily reporting disappearances.

We ran a simple one-way repeated measures ANOVA with flicker-frequency as the main variable. Our results showed a large main effect of flicker-frequency. We also found that disappearance times were largest in trials with a flicker of 1Hz compared to the other three flicker frequencies. The results allow us to elucidate a temporal regularity in showing how visual content is maintained in awareness in a binocular rivalry setup. It also shows how disappearance duration is linked to the periodicity of slow oscillations as predicted by theories of specious present and psychological nows. More importantly, it shows that the temporal regularities of content entering into awareness is not the same as content devolving from awareness. This shows that visual content unfolds asymmetrically in time. Overall, this is one experiment in a series of studies we have done and are doing to investigate temporal regularities of experience. These studies enable us to identify these regularities using CFS flicker frequency as a perturbation tool over different perceptual tasks.

# Structural brain correlates of visual-spatial attention gradient

Mir, Suhail Rafiq*; Dhar, Dolcy; Gupta, Prakrati; Singh Varshs; Chakrabarty Mrinmoy
*IIIT - Delhi*

Introduction

Emotion conveyed by human face offers vital cue to our visual system enabling us to navigate our social world by judging its affect. Emotional cues direct limited attentional resources towards the apt spatial locations of the visual field1. This spatial redistribution of the visual attention is adaptive and facilitates social interaction. Our attentional systems are crucial for guiding behavior by integrating external sensory information with internal affective states. Extant research reveals a distributed brain network that extends across the frontal and parietal cortices, collectively contributing to the control of visuospatial attention2,3. Much like various other neurocognitive functions, we hypothesized that the anatomical basis for spatial attention relies on key regions of large-scale neurocognitive network4,5. Earlier brain lesion studies suggested a mapping between brain structure and behaviour6, e.g., attention7,8. Thus, exploration of brain structure – behaviour associations are relevant to complement the functional brain studies towards better explaining higher cognitive functions9-11. The structural brain features linked with emotion-evoked biases of visual-spatial attentional distribution is incompletely understood, which we attempt to elucidate in this ongoing study Using measures from affect-primed, visual-spatial attention task coupled with structural magnetic resonance imaging (gray matter volume and cortical thickness) in healthy young adults, our preliminary results show specific structural features of the brain regions (left superior frontal gyrus, left supramarginal gyrus, left postcentral gyrus & and right middle posterior cingulate gyrus) that significantly correlate with the inter-individual differences in the gradient of visual-spatial attention. These results shed light on the structural brain correlates of visual-spatial attention biased by socially relevant affective cues in a dynamically changing environment.

Method

In this ongoing study, we have recruited 43 healthy participants (17 females; age = 23.16 ± 3.9 mean ± SD). Participants performed a gero-cognitive exam (SAGE) prior to the commencement of the experiment to ensure their cognitive function12. For the present study, participants with a baseline score >17 were recruited (20.62 ± 1.19 mean ± SD)12. Additionally, all participants answered a Spatial Anxiety Questionnaire (38.0 ± 14.6 mean ± SD) and those with baseline score > 36 were judged to be with normal spatial processing abilities13 and included. In the behavioural arm of the study, we used a modified affect-primed visuo-spatial attention task inform an earlier study14, with a key difference of using only the eye and eyebrow region of faces (specifically, the average perpendicular Euclidean distance between the pupil and the eyebrow from two eyes) serving as the affective cue considered salient in emotion information processing15. From this task, a composite metric for attentional efficacy (negative inverse efficiency score14, nIES) at three different eccentricities (1.5, 3, 6 degrees) was calculated from the reaction time and accuracy measures. Next,the gradient for each participant was calculated by taking a difference between the nIES scores at the nearest and farthest spatial eccentricity respectively from the source of emotion signal (Neutral, Fear, Scrambled).

The gradients were used for all further analyses. Separately, participants underwent a T1-weighted structural magnetic resonance imagining (sMRI) scan for the brain structure within a gap of seven days or less. The behavioural data was analyzed with custom scripts written on MATLAB 2022a and the sMRI data was analyzed using the Computational Anatomy Toolbox (CAT 12 version 12.8.2, r2170) hosted on MATLAB 2022a for estimating brain regional grey matter volume (rGMV) and brain cortical thickness. Regression analyses were done between the visual spatial attention gradient with rGMV and brain cortical thickness measures respectively. For all purposes a threshold of $p < 0.05$ was considered statistically significant.

Results

While we confirmed that the facial feature (average Euclidean distance between pupil and eyebrows) between the Neutral and Fear emotion signals varied significantly ($t(178)= 95\%$ CI = [55.93, 58.41], $p = 0.005$, Cohen's $d = 0.70$), our behavioural results returned no difference of attention gradients across the different levels of affective prime (Neutral, Fear and Scrambled on a Friedman's test ($X2 = 0.65$, $p = 0.72$, Kendall's $W = 0.14$). Thus, we averaged the nIES scores across three levels of affective prime for each eccentricity to calculate the overall attention gradient between near and far eccentricities relative to the source of the emotion in signal. This measure was then used to investigate the structural brain correlates of visual spatial attention gradient with the MRI arm of the study as follows.

Upon performing Pearson's linear regression between the rGMV of a few a anatomical brain regions of a priori interest (ROIs) with the overall attention gradient and controlling for confounding variables (age, gender, total intracranial volume), we found a significant negative correlation in left superior frontal gyrus that survived correction for multiple comparisons within the extent of the ROI ($x = 16$, $y = 32$, $z =54$; $t(38) = 4.98$, $pFWE = 0.02$, $kE = 24$).

Next, a similar analysis between the cortical thickness estimates of a priori ROIs and the overall attention gradient revealed a significant negative correlation (after correction) between the cortical thickness and the visual spatial attention gradient within the left supramarginal gyrus ($x = 46$, $y = 66$, $z = 30$; $t(39) = 3.77$, $p = 0.008$), left postcentral gyrus ($x = 20$, $y = 46$, $z = 56$; $t(39) = 1.77$, False Discovery Rate-corrected $p = 0.004$) and right middle posterior cingulate gyrus ($x = 5$, $y = 51$, $z = 38$; $t(39) = 1.92$, Holm-Bonferroni corrected $p = 0.031$) respectively.

Discussion

We investigated the brain structures (rGMV and cortical thickness) associated with emotion-cued biases in the deployment of attention to the visual space (indexed by attention gradient) We found that the rGMV of left superior frontal gyrus scales negatively with the attention gradient. A similar association was also evident with the cortical thickness of the left supramarginal gyrus and postcentral gyrus as well as right middle posterior cingulate gyrus. This implies that greater attention spatially closer to the emotion cue relative to far in individuals relate to lesser rGMV and cortical thickness of the above brain regions respectively. These brain regions may thus be further explored for objective brain-based metrics of emotion-cued tunnel vision in young adult individuals. Further, as the above brain regions have also been linked with monitoring salient emotional information, maintaining task attention, and facilitating response selection1,14 , our results could offer additional insights on emotional modulation of visuo-spatial attention (emotion and attention), which is a critical factor in affective states and disorders, e.g., anxiety.

**Dysregulated mental effort may be responsible for poor performances in saccade tasks in obsessive-compulsive disorder but not in schizophrenia: a combined eye-tracking and pupillometric study**

Nayok, Swarna Buddha*; Sreeraj, Vanteemar S; Chhabra, Harleen; Pathak, Harsh; Bose, Anushree; Shivakumar, Venkataram; Kalmady, Sunil Vasu; Narayanaswamy, Janardhanan; Reddy, Y C Janardhan ; Venkatasubramanian, Ganesan

*NIMHANS*

Introduction:

Mental effort is defined as a neurocognitive process that reflects the controlled expenditure of psychological information-processing resources during perception, cognition, and action. This multi-layered processing is often dysregulated, both qualitatively and quantitatively, in psychiatric illnesses. Furthermore, simple and complex eye movement-related visual processes are found to be abnormal in such illnesses. A combination of eye-tracking experiments with pupillometry may inform us regarding common underlying mechanisms of such abnormalities. Poor saccadic control commonly seen in schizophrenia may thus have cognitive basis and on the other hand, dysregulated mental effort hypothesised in OCD may present as saccadic abnormalities. Here we use combine eye-tracking and pupillometry to evaluate saccade-related tasks in those with schizophrenia (SCZ) and obsessive-compulsive disorder (OCD) and compare with healthy controls (HC).

Methods:

Eye tracking and pupillometry data acquisition and analysis were done with an SR Research EyeLink 1000 system. Two types of saccade-tasks were used, pro-saccade (PS) (where the participant had to look at the direction of the stimuli) and anti-saccade (AS) task (where the participant had to look at the opposite direction of the stimuli). Each participant (purposive sampling) performed 24 PS trials and 48 AS trials (blocked after one another, with no task-switching otherwise). The instructions were verbally given only at the start of PS and AS tasks. A gap-saccade paradigm (where the initial fixation point is followed by a brief period of blank screen (for 200 ms) followed by a target point) was used. We excluded saccades having latencies either <80ms or >600ms (representing either anticipation of the target stimulus or the participant not paying sufficient attention to the task), trials in which the first saccade was in the correct direction but the eye crossed over the midline and looked close to/at the target during the trial and the trials where the participant was looking out of the screen. We identified AS trials as erroneous if the first saccade has a latency between 80 and 600ms, but the saccade direction is towards the target. AS error percentage was defined as the ratio of erroneous analysable AS trials to the total number of analysable AS trials.

Pupil diameter (PD) was evaluated as a measure of cognitive effort and was measured through the inbuilt SR Research EyeLink 1000 system algorithm. Three stages were selected from each trial- 200 ms at the start of the initial fixation (FS), 50 ms at the end of the initial fixation (FE) and 50 ms at the end of the gap (blank screen) before the stimulus presentation (GE). FE and GE were taken as the preparatory phase, and FS served as the baseline. As the in-built PD measurement does not include data interpolation following blink correction, time-series analysis was avoided, and therefore the experiment was epoched into these three stages. The phase was excluded from the trial if there was a blink during that duration (200ms or 50ms). To perform the tasks correctly, one must exert more mental effort during GE than in FE. Independent samples Kruskal-Wallis with post-hoc Bonferroni correction and Friedman test were applied for between and within group comparisons.

Results:

We evaluated 68 HC, 68 SCZ and 96 OCD patients. The mean error percentage was highest in SCZ (M = 66.3825, SD=26.54579), followed by OCD (M=58.3639, SD=26.4771) and HC (M=38.2494, SD=25.0268) in AS task only and was significantly different across the three groups ($p<0.001$), with significant differences between HC vs OCD ($p<0.001$), HC vs SCZ ($p<0.001$) and SCZ vs OCD ($p=0.019$). Error percentage in the PS task did not show any significant differences. There were significant differences in the three groups in several saccade-related parameters like correct trials (HC>OCD>SCZ), errors (SCZ>OCD>HC), uncorrected errors (SCZ>OCD>HC), mean primary saccade latency (HC<OCD<SCZ), primary saccade amplitude gain (OCD>HC>SCZ), primary saccade peak velocity (OCD>HC>SCZ) in AS tasks (all with $p<0.001$). In all three groups, the mean PD of all stages in the AS task were significantly larger ($p<0.001$) than in the PS task, showing that increased mental effort is required for AS tasks. Further, PD in FS was significantly different across the group (OCD>HC>SCZ, H = 23,872, p=<0.001), with a significant difference between SCZ vs OCD ($p<0.001$), HC vs OCD ($p=0.002$) but not between SCZ vs HC ($p=0.77$). This shows that those with OCD may exert higher mental effort at the task's start, and therefore, we retained these baseline differences for further analysis. Across stages (FE, GE, FE), PD showed a trend of FS>GE>FE in all the groups. However, during the preparatory phase, the increase of PD from FE to GE was 0.59% in SCZ and 0.43% in HC but only 0.06% in OCD in AS, showing an inability to increase mental effort during the appearance of the blank screen.

Discussion:

SCZ group performed worse, followed by OCD in the AS task in most parameters, reinforcing previous such findings. Further, PD analysis showed that more mental effort was required in AS tasks in the preparatory phase than in PS. However, the dysregulation of mental effort was observed only in OCD as they failed to exert higher mental effort during the appearance of the gap in the AS task. Our findings perhaps also point towards autonomic dysfunction present in those with OCD and SCZ, where a higher baseline PD may show a pervasive state of anxiety in those with OCD. Such observations may, therefore, mean that although performance in saccade-tasks is poor in OCD and SCZ, the underlying mechanisms may vary - an already dilated pupil may leave a lesser ability to increase the PD in OCD further. In contrast, applying mental effort may be abnormal for those with SCZ. Such findings may help to quantify these disturbances in further studies, as despite having a greater PD, those with OCD performed better than SCZ, which further points towards dysregulation of mental effort in OCD but abnormal processing of mental effort in SCZ. Such intrinsic differences may serve as specific biomarkers for various psychiatric illnesses. Our limitations include using eye-tracker-related arbitrary units for PD, the inability to use time series data to further understand the course of PD throughout the tasks and the absence of further socio-demographic and clinical details.

**Exploring Pupil size changes in Schizophrenia: Implications for attention – A pupillometry study**

Pathak, Harsh*; Sreeraj, Vanteemar S; Nayok, Swarna Buddha; Chhabra, Harleen; Subramaniam, Aditi; Bose, Anushree ; Agarwal, Sri Mahavir; Shivakumar, Venkataram; Kalmady, Sunil; Narayanaswamy, Janardhanan; Venkatasubramanian, Ganesan
*NIMHANS*

Introduction:
Fluctuations in pupil size across time intervals can offer valuable insights into cognitive processes like attention (1). In individuals with schizophrenia (SCZ), as the task demand increases, a reduction in the dilatation of the pupil has been observed (2). This phenomenon is due to cognitive processing abnormalities resulting from cognitive deficits seen in SCZ. The pupil size changes secondary to attention shifts have been shown to indicate the activity of the locus-coeruleus nor-epinephrine (LC-NE) system (3). It's been postulated that a larger pupil size may indicate distraction and disengagement from the task secondary to LC tonic mode, leading to poorer attention (4). Dynamic pupillometry provides a simple and reliable method to assess attention allocation and cognition in general by measuring the pupillary indices across a time period during a task.
This research aims to explore the alternations in pupil size across time while participants, i.e. SCZ and healthy controls (HC), engage in a fixation stability task (FST). We enrolled drug-naïve/free SCZ (dSCZ) patients to reduce the confounding effects of antipsychotics.

Methods:
Design: Cross-sectional study
Participants: 30 dSCZ (Age:32.5 6.39 years, Males:15, Right eye dominance:21) and 30 HC (27.9 4.63 years, 17, 21).
Experiment: Before initiating the FST, the subject's ocular dominance was determined using the Dolman method. The pupillometry data was recorded using the subject's dominant eye. The visual stimuli were presented on a 22-inch flat screen monitor (Viewsonic) with a refresh rate of 120 Hz and a screen resolution of 1680×1050 pixels. This monitor was positioned at 74.3 cm in front of the subject. Pupillometry data were acquired using EyeLink 1000 (SR Research, Canada), with a sampling frequency of 1000 Hz. Subjects were provided clear instructions to minimize any physical movements throughout the experiment. Additionally, head movements were restrained using chin and forehead rest.
For the FST, subjects were instructed to maintain a steady gaze on a central 0.5° circular yellow target for 5 seconds and to ignore an identical flanking distractor target when present appearing either ±1.43° (near distractor) or ±2.86° (far distractor) on either of the side of the fixation target. The target-only (or fixation) condition was shown first, followed by the other four distraction conditions (near distractor or far distractor) in a fixed order. Each condition was repeated twice with a total of 10 trials.
Data processing and statistical analysis: The sample output report generated through EyeLink Data Viewer 1000 (SR Research, Canada) was pre-processed and analysed using the PupilPre package using the R project for statistical computing. The pre-processing involved data cleaning, interpolation of data, data filtering, data trimming, and downsampling the data to 10 Hz. Data cleaning involved removal of off-screen data, filtering trials with blink at or within 30ms of initiation of a trial, and blink and artefact removal. Post-data cleaning, the pupil data was reconstructed using linear interpolation, followed by smoothing using a third-order low-pass Butterworth filter with a critical frequency of 0.05. The data was trimmed to remove artefacts generated by filtering.
Independent T-test and ANOVA were used for between and within-group comparisons of pupil size. A baseline correction was applied to estimate pupillary size changes during periods of fixation and distraction between HC and dSCZ, and a percentage change in pupil size was calculated. A linear mixed-effect model was used to find any effect of diagnosis, time and condition (fixation with/without distractor) on change in mean pupil size time-locked to stimuli presentation, accounting for variations due to age, sex, and eye dominance.

Results:
In the FST, the mean pupil size across conditions was 2050 ± 823 in the dSCZ group, whereas in the HC group, it was 3057 ± 1058. This difference was significant ($t = 3.44$, $p < 0.001$). Moreover, a significant difference in mean pupil size between fixation and distraction conditions was noted for both HC ($F = 4.33$, $p = 0.037$) and dSCZ ($F = 5.04$, $p = 0.024$) groups.
Post-baseline correction, the mean percentage change in pupil size was 3.00 ± 11.09 for HC and 2.81 ± 14.46 for dSCZ ($t=3.44$, $p<0.001$). A linear mixed-effect model revealed a significant interaction effect of condition with time (estimate=0.002, $p<0.001$) and diagnosis with time (estimate=0.0004, $p<0.001$). In HCs, an initial phase of 1sec of mild dilation followed by constriction, which was followed by a second phase of progressive dilation of pupils, was noted over the 5-second period after presenting fixation stimuli. However, a sustained mid-pupillary dilation was noted in the second phase throughout the task period when distractors were presented alongside fixator stimuli. In dSCZ, an overall lesser dilatation was noted in the first phase in both conditions, whereas a delay in the latency for peak dilation was noted in the

non-distractor condition. Also, in trials with distractors, a delayed latency to achieve mid-pupillary dilation was noted in dSCZ, which did not sustain but progressed to further dilation till the end of the 5sec period.

Discussion:
The dSCZ group, in comparison to HC, had reduced pupil size, which could be linked to underlying autonomic dysfunction. As all the patients were not on antipsychotic medications, this finding suggests a direct relation with the pathophysiology of schizophrenia. Furthermore, in dSCZ, dynamic pupillometry revealed reduced pupillary dilations in the initial phase and increased latency for dilation in the second phase in both conditions, suggesting impairment in attentional allocation. Also, a progressive dilation associated with impaired stability in the fixation of eye movements points to impaired sustenance of attention, even for a brief period of 5 seconds. Future studies are needed to look at dynamic pupillometry to understand the association of pupil size with symptom severity that may be mediated by aberrant salience and neurocognitive dysfunctions in SCZ.
The study's fixed distractor order may bias responses. Future research should randomize distractor order, use z-scores (not baseline correction), and consider compensation algorithms such as geometrical model for foreshortening.

## Gaze dependence of Visual Working Memory representations

Raya, Deepak Velgapuni*; Sridharan, Devarajan
*Centre for Neuroscience*

Introduction:
Eye movements and visual attention are closely linked: gaze is automatically directed toward attention-demanding, salient stimuli. Similarly, visual attention is closely linked with visual working memory (VWM): attended items are generally retained in VWM, whereas unattended items are rapidly forgotten. Nonetheless, whether eye movements and visual working memory are linked is relatively unknown. Conventionally, it has been assumed that eye movements, which are useful for scanning external objects, cannot affect VWM because VWM is a stored internal representation within the brain. Yet, recent studies have challenged this hypothesis. Building upon these studies, we seek to understand mechanisms mediating the stability of VWM across gaze shifts.
Previous studies have described how VWM influences eye movements in diverse tasks [1]. However, the effect of eye movements (EM) on VWM is relatively unknown. Past research shows that items stored in VWM buffers in the brain hemisphere contralateral to the stimulus hemifield and that VWM buffers are independent across the brain hemispheres [2], [3]. However, it is not clear whether the information held in VWM is in retinocentric (gaze-relative) coordinates or allocentric (gaze-independent) coordinates. A recent study in non-human primate PFC [4] observed that the contents of VWM are transferred across brain hemispheres following a gaze shift to maintain a representation in allocentric coordinates. Yet, this study suffered from the shortcoming that the final judgment performed by the animal required an allocentric coordinate frame. To address the above questions, we quantified VWM representation in the brain using a metric derived from Event-related potentials (ERPs) and multivariate pattern decoding on EEG data while human participants performed an orientation discrimination task on grating stimulus, involving simultaneous saccadic eye shifts across the visual hemifields. Specifically, we trained a Mahalanobis distance-based decoder to discriminate between orientation-related EEG activity patterns [5].Our results show that the VWM is flexibly represented in the brain depending on the task demands induced by gaze shifts.

Methods:
Experiments:
We designed a VWM-based orientation discrimination task (Fig. 1). On each trial the participant must remember the orientation (angles drawn uniformly from ) of the initially presented grating. Midway during the delay, the fixation dot shifts in its position, and the participant must make a saccade as soon as this occurs. Post delay, the participant must report whether the probed (final) grating is rotated clockwise (CW) or counterclockwise (CCW) relative to the initial grating. To study the effect of gaze on VWM, we used two conditions: in one case, probe grating appears on the screen either at the same allocentric (gaze-independent) location as the initial grating or at the same retinocentric (gaze-relative) location. The conditions were blocked, each block has 125 trials. The task has a total of 8 blocks, alternating between the conditions. While subjects performed the task, we recorded their eye movements (SMI eye tracker) and EEG (Bio-semi-Active 2, 128 channels).
To study the performance of individuals on the task, we computed the percent accuracy and sensitivity () of discrimination, on trials belonging to each angle difference between stimulus and probe gratings. In the task, we have used seven discrete angle differences similar to [5]. The resulting average accuracies from 16 participants were fit with a sigmoid function.
Quantifying VWM representations:
We collected EEG data from 16 participants while they performed the VWM task. To test our hypothesis, we used an ERP-based metric called contralateral delay activity (CDA) computed as the difference between Contralateral and Ipsilateral ERPs, which is known to be a neural correlate of VWM maintenance and is a function of VWM loading [6]. Electrodes corresponding to PO7/8, P7/8, and O1/2 locations in a 10-20 system were used for computing the CDA.
To decode VWM representations, we trained a Mahalanobis distance-based decoder using EEG data at each time point and predicted the presented (or remembered) orientation using a leave-trial-out method. This results in a decoded tuning curve () relative to the presented orientation for each time point. A dot product between the tuning curve and a half-cosine curve was used to quantify decoding accuracy. Here we pooled and stacked the EEG data in a window of 300ms width (timestamped at the center) to get the feature vector and reduced the dimensions by selecting the principal components that explain the 95% variance before giving it as an input to the decoder.

Results
The performance (accuracy) on the retinocentric condition was higher than in the allocentric condition (Fig. 2A), indicating that the participants found it more challenging to perform the task when the probe appeared in the opposite hemifield as

compared to the initial stimulus despite them being in the same physical (allocentric) location in the world! We observed that the CDA for the allocentric condition was also weaker than that for the retinocentric condition during the working memory delay period before the saccade shift (Fig. 2B). This suggests that in the allocentric condition memoranda were perhaps represented bilaterally, as compared to the retinocentric condition where they were represented largely contralaterally. Moreover, the decoding accuracy for ipsilateral electrodes was higher than for the allocentric condition compared to the retinocentric condition around the saccade onset (Fig. 3), but not in the contralateral condition. This could be a signature of transfer in VWM representations from one hemisphere to the other in allocentric condition but not in retinocentric condition, which is in accordance with the hypothesis of flexible representation of VWM.

Discussion:
Our results from both CDA and decoding accuracy suggest that transfer of VWM across brain hemispheres occurs in the allocentric, but not in the retinocentric condition. The results indicate a flexible representation of VWM in the brain depending on task demands. This flexible representation in turn could drive the stability of VWM across gaze shifts.

## Modulation of implicit motor learning by reward

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Introduction:
The capability of our sensorimotor system in generating precisely calibrated movements depends on its ability to learn from environmental errors. This learning is driven largely by sensory prediction errors, which reflect discrepancies between the actual sensory outcomes of an action and the outcomes predicted by an internal model of the sensorimotor system. While this is well-acknowledged, there is controversy about whether and how reward influences such learning. For example, some studies suggest that reward does not modulate learning but enhance the retention of what has been learned (Galea et al., 2015). However more recent studies suggest that reward might modulate learning itself (Kim et al., 2019). Here we sought to investigate the influence that reward might have on prediction-error-driven learning. We predicted that if accurate reaches by the hand to its intended location are rewarded, such learning - induced via a discrepancy between visual feedback of hand motion and its actual motion - can be arrested, thereby revealing an inhibitory influence of reward.

Methods:
A total of 72 young, healthy, right-handed subjects participated in this study. Subjects were randomly assigned to two task conditions: "simple" and "complex". These conditions were further subdivided into three groups: "no reward," "visual reward", and "visuo-proprioceptive reward." The primary task involved participants executing point-to-point reaching movements by holding the handle of a robotic manipulandum and moving it from a starting position to reach one of two targets (for the simple tasks) or one of eight targets (for the complex tasks). Targets were positioned at a radial distance of 12 cm from the initial starting position. The experimental protocol consisted of three blocks: baseline, learning, and washout. During baseline and washout, the movement of a cursor displayed on a screen was veridical with the actual motion of the participants' hands. Participants moved with or without visual feedback from the cursor during these blocks. In the learning block, a critical manipulation was introduced: the motion of the cursor was made incongruent with hand motion, and it consistently moved in a predetermined direction that was rotated relative to the participants' hand movements. Participants were explicitly informed about this manipulation and were instructed to ignore the cursor. Rather, they were instructed to focus exclusively on moving their hand directly to the visible target, and were provided with reward feedback for successfully hitting it. The reward took the form of a smiley for the visual reward group, and both a smiley and a small force pulse applied to their hand for the visuo-proprioceptive reward group. The "no reward" group did not receive any such reward. This design enabled us to investigate whether participants can use the reward information to suppress learning from sensory prediction errors created by the incongruent cursor feedback.

Results:
Our preliminary data revealed an interesting influence of task complexity on learning behaviors. In the context of the complex task condition, all participant groups exhibited a similar learning pattern, regardless of whether they were exposed to reward. Furthermore, all groups displayed comparable aftereffects, a characteristic hallmark of implicit learning. This suggests that reward did not exert any influence, highlighting the mandatory and intrinsic nature of sensory-prediction-error-driven implicit learning. However, in the case of the simple task condition, a divergence in performance was observed. The two groups that received reward demonstrated an attenuation of implicit learning compared to the control group that did not receive any reward. This divergence was present in both the learning phase and the subsequent aftereffects, suggesting that reward information was somewhat influential in modulating implicit learning. Notably however, when we compared the two reward groups: the "visual reward" and "visuo-proprioceptive reward" groups, no difference in either the learning phase or the subsequent aftereffects was observed. This observation suggests that the introduction of additional information regarding task success, facilitated by visuo-proprioceptive feedback, did not yield any improvement beyond what was achieved with visual rewards alone. We are firming up these analyses with data from additional subjects and appropriate statistics.

Discussion:
This study investigated the influence of reward-based learning on motor adaptation. We found a small and subtle modulation of implicit learning by reward in a less complex task. This suggests that when tasks are simpler, the presence of rewards can alter participants' reliance on sensory prediction errors, potentially affecting the learning process. However, this fails when task complexity increases; in such cases it is nearly impossible to tune learning from sensory prediction error. The modulation, at least in conditions of low task complexity, suggests that there might be some interaction or overlap between the neural areas that process reward and those that drive implicit learning.

**Complex Waves and their role in memory**

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Introduction:

Complex spatiotemporal patterns of neural activity have been reported in humans as well as other animals. While their functional role is not well understood, they allow for interactions between neural populations and are believed to play a role in information processing by influencing neuronal spiking. That said, notwithstanding a growing literature on planar travelling waves (PTWs) in the human brain (Zhang et al. (2018)), reports of complex non-planar patterns (NPPs) — such as spirals, sinks, and sources — and how they relate to cognitive processing remain scarce. For example, spiral waves have only recently been investigated at the whole-brain level.1 (Liang et al. (2023))

In this study, we describe a variety of micro-scale complex waves in the local field potential (LFP) in the human brain on the occasions of memory formation and retrieval. We reanalyzed recordings collected using 96-channel microelectrode arrays (4 × 4 mm; Blackrock Microsystems; 30 kHz) implanted in the middle temporal gyrus of five participants, admitted for epileptic monitoring, as they performed a paired-associates verbal memory task in multiple sessions.2, 3

Methods:

The pattern-detection-method has been largely adopted from Townsend et al. (2018) with some modifications:

1. The recording was low-passed at 500 Hz to extract the LFP, and down-sampled to 1 kHz.
2. 5s long epochs for two study-conditions — preceding the recall and succeeding the display of the word pair — were extracted after suitable preprocessing including removal of 60 Hz line noise, noisy channels and trials, and robust global average re-referencing (Cheveigné et al. (2018)).
3. Instantaneous phases were evaluated by the Generalized Phase algorithm (Davis et al. (2020)) to avoid distortion from application of narrow-band filters. Briefly, this involved (in succession): filtering out the very-low frequency content, running a one-sided Fourier transform, computing phase derivatives as finite differences, and interpolating around the high frequency intrusions since they led to meaningless negative phases).
4. Phase velocity fields (PVFs) were iteratively estimated using a modified version of Horn-Schunck optic flow algorithm.
5. PTWs are detected when the phase velocities undergo near-complete alignment across the entire array; synchronous activity — or standing waves — are detected when the instantaneous phases align.
6. Borrowing from linear stability analysis techniques, seven spatial patterns were categorized. At each time-point, we identified the critical points from the intersections of all (interpolated) null clines of the velocity field and then, evaluated the Trace and Determinant of the local Jacobians by interpolating from the (four) adjacent grids:4
    a. Det < 0 --> Saddle.
    b. Det > 0 & Tr2< 4*Det & Tr < 0 --> Spiral-out.
    c. Det > 0 & Tr2< 4*Det & Tr > 0 --> Spiral-in.
    d. Det > 0 & Tr2> 4*Det & Tr < 0 --> Source.
    e. Det > 0 & Tr2> 4*Det & Tr > 0 --> Sink.
7. Temporally successive patterns of the same kind were subsumed into one spatio-temporal NPP if the critical point never moved too far away (<= 1 grid) in a single time-step, and the resulting wave persisted for a bare minimum time (var. across hypotheses).
    a. Waves as detected in micro-epochs of 2s right after the display of the word pair and right before the recall of the word were subject to analysis because we expected evoked activity to be at its peak during these spans.
8. A surrogate dataset was created by randomizing the phase of the Fourier components of the raw signal (Prichard et al. (1994)) and applying Steps 1 to 6.

Time-Frequency Representation (TFR) was performed via MNE using 4-cycle Morlet wavelets with 49 logarithmically spaced center frequencies ranging from 2 to 100 Hz. (Gramfort et al. (2013))

To verify a pattern transitioning into another in the physical sense is a difficult task and we adopted Townsend et al. (2018)'s definition — a transition-event is two patterns following within 50ms of each other.

We performed Singular Value Decomposition on the Phase-Velocity Fields to identify the principal components of the patterns and thus, document the dominant wave propagation pathways. (Townsend et al. (2018))

Results:

Result 1: Upon presenting stimuli, there is an increase in power in around 2-4 Hz for both the subjects.5 A representative TFR plot for one session of a subject for one of the study-conditions follows:

Result 2: In all the subjects, across all sessions, saddles followed by spirals were the most predominant NPPs throughout the recording interval. They far-exceeded PTWs and synchronies.6 Representative plot for a subject follows:

Result 3: In all subjects, for both the study conditions under consideration, all NPPs transitioned (see discussion) at a statistically significant rate (Fisher's $p < 0.05$) when compared to that of surrogate data.7 Representative heat-map for a subject for one of the study-conditions follows:

Result 4: For a representative subject, PPW is the most influential mode across all sessions at 23.85% (mean) of total variance; spiral-in and saddle follow next but only for four of the six sessions accounting for 19.15% (mean) of total variance. All the remaining modes are random (ex: Modes 4 and 5 in Fig. 4). A representative plot follows:
Presentation of stimuli affects power at around 4Hz for about the succeeding 2s. Saddles and spirals dominate other patterns across the entire recording span; these observations fit with Liang et al. (2023)'s for the wakeful state.8 We did not find the frequency-of-occurrence of NPPs to alter significantly upon stimulus.
A NPP transitioned into itself or some other pattern with a greater preference (i.e., they were more temporally squeezed) than would be expected by chance. Additionally, the top three SVD modes remained common across subjects demonstrating the typical wave propagation pathways; however, the large number of minor modes varied extensively, attesting to the rich dynamics.

Future directions:
Mohan (2022) correlated certain characteristics of PTWs to the accuracy of memory recall and elucidated how these waves influence memory encoding and decoding. The predominant directionality (or lack, thereof) and phase of PTWs were, respectively, good predictors of successful encoding and time delay in recall.
While initial explorations in such a direction for NPPs have not been fruitful, we are currently analyzing differences between baseline restful states and general memory processing in terms of prevalence and/or features of complex waves. We also aim to probe into whether these NPPs coordinate spiking activity.

- They have also been reported at the micro-scale in the macaque brain. (Townsend et al (2015).
- In each round, six word-pairs were displayed on the screen followed by a diversion task pending which the patients were shown one of the words from each of the pair and had to recall the other word. Typically, 25 rounds were conducted in what was a continuous session; words and word-pairs were repeated. A patient usually partook in five or six sessions on different days.
- The experiment was conducted at the Clinical Center at the National Institutes of Health. NIH Institutional Review Board approved the protocol, and we obtained informed consent from the participants and/or their guardians.
- Det = Determinant; Tr = Trace. All interpolations were bilinear.
- Baselined relative to -100 to -400 ms.
- However, as Liang (2023) notes, PTWs and synchronies exceed if calculated as local events, say, by portioning the array into many grids.
- Here, a threshold of 2s was imposed since waves transition to one another through very short-duration waves.
- We applied a 10s threshold to define a meaningful wave. In contrast, Liang et al. (2023)'s sampling rate of 150 Hz ensured a minimum duration of 6.66 ms and no threshold had to be imposed.

## Reading from beginning to skilled readers: A comparison between alphabetic and alpha-syllabary writing systems

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Introduction:
Learning to read is a dynamic journey that extends beyond the classroom, encompassing cognitive growth, language acquisition, and social interactions. The process strengthens with age. The pace and trajectory of the journey from beginning to skilled reading can vary significantly across languages due to their unique orthographic properties. Feng et al. (2009) and Jincho et al. (2014) have shown developmental changes and orthography-dependent changes in eye movement measures in different orthographies like English, Chinese, and Japanese. The study by Nag (2007) showed a slower learning rate for Kannada than in English, suggesting language-specific characteristics like multiplicity of graphemic symbols, and non-linearity make the whole learning process slow. Nevertheless, once it is learned, the reading is faster than in English (Pandey, Padakannaya 2011). The present study explores eye movement patterns while reading two distinct orthographies: Kannada and English, from a developmental perspective. As Kannada differs from English in grain size, number of symbols (syllabogram), and visual complexity of syllabograms, we hypothesize that learning to read Kannada would take longer than English.

Method:
Seventy-five children aged 7-8, 10-11, and 13-14 years (25 in each group) read English and Kannada sentences- simple, complex, and jumbled ones- in different sessions. Their eye movement patterns were compared with that of adult readers (25 in number). All the participants had normal or corrected to normal vision.

Results:
We recorded the following eye movement measures; (1) reading time per word, (2) fixation count per word, (3) total fixation duration per word, (4) Progressive fixations per word, (5) regressive fixations per word, and (6) scan path length per word. For the factorial design 4 (age groups; 7-8, 10-11, 13-14 and adult) X 2 (languages; Kannada and English) X 3 (sentence types; Simple, Complex and Jumbled) multivariate analysis of variance (MANOVA) was performed followed by univariate analysis of variance*. From the multivariate analysis, it was found that the main effects of age groups ($F(3,576) = 170.34$, $p < 0.001$, $\eta 2 = 0.46$), languages $F(1,576) = 488.46$, $p < 0.001$, $\eta 2 = 0.47$), and sentence type ($F(2,576) = 9.06$, $p < 0.001$, $\eta 2 = 0.03$) as well as the interaction between language and age groups ($F(3,576) = 64.91$, $p < 0.001$, $\eta 2 = 0.25$) were significant for reading time per word. Other interaction effects were not significant. It was observed that the main effect of age group, language, and sentence type was significant for all the eye movement measures- fixation count per word, total fixation duration per word, and progressive and regressive fixations per word. Also, the interaction between age groups and language was significant for these variables. Further, from the univariate test, it was observed that in reading, the English 13-14 age group was not significantly different from the adult group ($p>0.05$) for all the dependent measures. However, in Kannada, all the age groups were significantly different from each other for reading time per word, fixation count per word, and total fixation duration per word. Progressive and regressive fixations were not different when comparing 10-11, 13-14, and adult groups. For scan path length, only 10-11 vs. 13-14 was not different other comparisons were significantly different. Results show that eye movement measurements have reached asymptotes in English at 13-14 but not in Kannada. Univariate analysis of sentence types suggests that there is not significant difference in simple and complex sentences, however, eye movement measures of jumbled type sentences are significantly difference with simple and complex type sentences.
The results showed that younger children exhibited more fixations, progressive and regressive saccades, longer reading time, and longer scan path lengths compared to their respective elder groups in both languages.

Discussion:
The results showed children became skilled reader sooner in reading English at a younger age, i.e., 13-14 years as compared to reading Kannada. The findings are interpreted in the light of cognitive processes involved in learning to read different orthographies. The orthographic properties of a language significantly influence how learners approach reading, the pace of their progression, and the strategies they employ.
English includes a lesser number of graphemes, which may enable learners to master it quickly. Perhaps a larger exposure and practice effect (as the schools were English medium) may have also accelerated the development of reading fluency. However, the orthography of Kannada includes a multiplicity of graphemes i.e. for each additional phonological symbol (‘matra’) there is an addition of the whole set of symbols. The multiple symbols of Kannada make it difficult for young children to remember the whole graphemic set.

While alphabetic orthographies like English might have a quicker initial reading acquisition phase due to their smaller grain size, it's important to consider the broader context. Reading proficiency levels and cognitive processes can vary significantly among individuals, and various factors beyond the writing system, such as instructional methods, language exposure, and individual learning styles. Thus further investigation in this direction is essential.
Educators and researchers must take these variations into account when designing literacy instruction and interventions. Adapting teaching methods to align with the orthographic properties of a language can optimize reading development and support learners in becoming skilled readers.

* The Kolmogorov–Smirnov test of normality suggests that the data is normally distributed ($p < 0.01$).

Keywords: Language acquisition, Reading, Grain size.

# Explaining Word Order Variation during Language Production as a Trade-Off between Communicative Efficiency and Planning Ease

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Introduction

Linearization of sentential arguments during language production has been an important area of research in psycholinguistics [1]. One of the factors found to influence linearization is argument length—number of words constituting that argument [2]. In Subject-Object-Verb (SOV) languages, a long-before-short word order preference has been observed (e.g., Japanese [3]; Basque [4]; Persian [5] etc). That is, when formulating a sentence consisting of a long and a short argument, speakers of SOV languages prefer to place the longer argument before the shorter argument.

The cognitive underpinning for a long-before-short preference is that it minimizes the total dependency distance of the sentence. Assuming limited memory resources, shorter dependencies (distance between syntactic heads and dependents) reduce the overall effort associated with processing the sentence and make production more efficient (c.f., Dependency Locality [6]).

While dependency locality is linked to functional efficiency, it also entails non-incremental planning during production, i.e., speakers would have to structurally plan both long and short arguments to be able to ascertain the linear order which would minimize dependency distance.

However, planning during production is highly incremental [7]. In an incremental framwork, speakers follow the easy-first principle [8], preferring to plan easy elements of a sentence before the complex ones. Shorter arguments are considered 'easy' in terms of planning because they contain fewer words and are syntactically less complex. This account predicts that short arguments appear first and languages follow a short-before-long order.

In SOV languages, the two accounts outlined above make competing predictions about the direction of length-guided shifts. Efficiency predicts a long-before-short order but also entails non-incremental planning. Easy-first aligns with incremental planning but predicts a short-before-long order, contrary to what has been found for SOV languages so far.

One factor known to induce incremental planning is time-pressure. For instance, people switch from non-incremental to incremental planning when working under a deadline procedure [9]. Based on this rationale, in a set of two experiments (Exp1 and Exp2), we investigated the direction of length-guided shifts when speaking with or without time-pressure using Hindi, an SOV language.

Methods

Both experiments used the same design with the difference that in Exp1 participants were given ample time to speak their sentences, while in Exp2 they were operating under a deadline. Transitive (SOV) sentences constituted the critical items in both the experiments. The length of the arguments was modified using prenominal modifiers and had 3 levels of manipulation: All-Short, Object-Long, and Subject-Long (see Table-1 for sample items). The dependent variable was the percentage of Object-fronted (OSV) sentences.

Task Design

The paradigm used was the sentence-recall task [3, 4]. This task allows us to investigate ordering preferences during naturalistic production under controlled settings [10]. Participants (n=126; Exp1=84; Exp2=42)1 viewed the subject, object, and verb as fragments in different boxes on the screen (Screen-1 in Fig-1) and were asked to construct a sentence with them. Following a distractor (arithmetic problem; Screen-2 in Fig-1), they were given the verb as cue (Screen-3 in Fig-1) to speak aloud the sentence they had prepared, and their responses were recorded.

Predictions

The predictions for the experiment were preregistered on OSF.

If speakers prefer a long-before-short order, then OSV responses in the Object-Long condition should be significantly more compared to the All-Short (baseline). If, speakers prefer a short-before-long order, then there should be significantly more OSV responses in the Subject-Long condition compared to the All-Short condition (c.f., Table 2)

Now, if time-pressure influences the direction of shifts then we predict an interaction effect such that the short-before-long pattern should be observed only in Exp2 and not Exp1.

Results

Fig-2 sums up the percentage of OSV shifts for different levels of length manipulation in both the experiments.

Generalized linear mixed effects models with the logit link function were fit to the data using the lme4 package in R. Two sets of models were run to test the predictions of long-before-short and short-before-long separately. The models included Experiment-ID, Length and the Interaction between them as fixed effects. All factors were treatment-coded. The major findings are as follows:

Model-1: long-before-short (Table-3)

- OSV sentences were significantly more in the O-Long condition compared to the All-Short condition indicating that participants preferred the long-before-short order across both experiments.
- There was also an interaction between Experiment-ID and long-before-short such that the long-before-short preference was stronger when speakers were working under time-pressure compared to when they were not.

Model-2: short-before-long (Table-4)

- Surprisingly, OSV responses were significantly more also in the S-Long condition when compared to the All-Short condition across both experiments indicating that participants also preferred the short-before-long order (though it's magnitude was less compared to long-before-short).
- Contrary to predictions, no interaction with Experiment-ID was observed here indicating that time-pressure did not increase the propensity to speak sentences in short-before-long order.

Discussion

- While languages have usually been found to align with either a long-before-short or short-before-long order, we provide novel evidence for both orderssimultaneously determining word-order choices in a single language. This suggests that planning during production is a trade-off between functional-efficiency and planning-ease.
- Stronger effect of long-before-short combined with no evidence for increase in short-before-long when under time-pressure indicates that planning sentences such that dependency distance is minimized might not be costly as is assumed by incremental models of sentence production. Dependency locality seems to be a cognitively grounded principle which gets highly activated when put under time-pressure.

Exp1 had twice the number of subjects because it had another manipulation which is not relevant to the current discussion. Sample size was determined after a power analysis using simr package in R

# Effects of Grammatical Gender on Object Categorization in Native Hindi Speakers

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Introduction

According to the linguistic relativity hypothesis, linguistic elements can influence other cognitive processes such that speakers of various languages have slightly different worldviews (Whorf, 1956). One such aspect of language that has not received enough attention until recently, is grammatical gender (Boroditsky, et al. 2003; Samuel et al., 2019; Philips et al., 2013;). Grammatical gender is widely considered as a syntactic phenomenon in language, separate from semantics. (Arnoff, 1994; Cubelli et al, 2008). Recent research has, however, shown that native speakers of gendered languages have different mental representations of objects depending on the grammatical gender assignment of their language (Sera et al., 2002; Kurinski, 2011; Almutrafi, 2015; Maciuszek et al. 2019). Despite several such studies existing for many gender languages of European and some Semitic language families (Bassetti, 2016), there is a dearth of literature on gender studies in Hindi, one of the most spoken gendered languages of the world (Charunrochana, 1999; Mukherjee, 2018).

All nouns in Hindi are divided into two grammatical gender classes, masculine and feminine. A native Hindi speaker must be aware of this classification to make inflections to other word classes such as adjectives and verbs when used in sentences. The goal of the current study was to understand if the linguistic component of grammatical gender has an effect on the semantic representations of objects in native Hindi speakers. The study used a semantic categorisation task that does not explicitly mention the usage of gender, and found that gender effects are observed in the latency of categorisation. This implies the implicit activation of gender of objects in a semantic task of categorisation in Hindi speakers.

Methods

Thirty native Hindi speakers with a mean age of 19.7 years, (S. D=1.46) participated in the study. On a computer screen, each participant was asked to perform a category membership judgement task that was adapted from Cubelli et al. (2011). Participants had to determine by key-response whether a pair of Hindi words corresponded to the same semantic category (such as vegetables, garments, etc.). The two alternative keypresses could be either 'Yes' or ''No' for semantically related and unrelated word pairs, respectively. Further, these two trial conditions could be either gender congruent or gender incongruent. This results in four types of word pairs: semantically related-gender congruent, semantically related-gender incongruent, semantically unrelated-gender congruent, and semantically unrelated gender-incongruent. A group of 30 native Hindi speakers (of the same region as the experimental sample) rated the stimuli for frequency, familiarity, and grammatical gender agreement. There were words from four semantic categories: vegetables, food items, apparel and accessories, and household items. Two masculine and two feminine words from each category (16 words) were paired with words from the same and different gender and semantic category to form 64 pairs. Similarly, 64 filler pairs were also created. The experiment consisted of one block of 128 trials presented in a pseudorandomized order. The pseudo-randomisation constraints were: (i) consecutive trials were not of the same category, (ii) semantically related or unrelated conditions, and gender congruent or incongruent conditions did not occur for 3 consecutive trials, (iii) the first four trials of the block were filler trials, (iv) remaining fillers appeared randomly between critical trials. The experiment was created using E-prime software 3.3.0 (Psychology Software Tools, Pittsburgh, PA) and displayed on a computer screen with a refresh rate of 60 Hz. The trial sequence included a 500ms fixation cross followed by a pair of words presented in Devanagari script till keypress or up to 4000ms. This was followed by a 500ms period of blank screen. After the task was completed, participants were asked to rate the semantic relatedness of the words of critical trials on 7-point Likert scale of semantic relatedness, to compare the individual variations in judged semantic relatedness of the stimuli.

Results

The analysis only included the critical trials. Participants having a mean accuracy of less than 75% (20% of the total data) were removed. For the binary key-response task, the mean accuracy of all participants was 82.03% (S.D.=4.62).

The analysis only included latency measures from participants with mean accuracy greater than 75%. Further, 26.17% of data were removed for categorisation errors or blank responses, and 8.13% of data were removed for being extremely latent responses (above 2,500ms). The effects of extremely short or long latencies were removed by replacing outlying data of each participant with their mean+- 2 S.D. values (Cubelli et al. 2011).

The response latencies were subjected to a 2x2 repeated measures ANOVA, with semantic relatedness (semantically related or unrelated), and gender congruency (congruent or incongruent), as within subject factors. There was no significant main effect of semantic relatedness, $F(1,23) = 0.799$, $p = 0.381$. Gender congruency showed significant main effect, $F(1,23) = 4.702$, $p = 0.041$. The interaction was not significant $F(1,23) = 3.050$, $p = 0.094$.

Thus, irrespective of semantic relatedness, gender showed an effect in the categorisation task. In both semantic relatedness and unrelatedness conditions, response latencies of gender congruent conditions were significantly lower than gender incongruent conditions.

Analysis of subjective judgement of semantic relatedness of stimuli by participants showed that the mean rating of semantically related word pairs was 4.57 (S.D. = 1.72) out of 7. The mean rating of semantically unrelated w

1.25 (S.D = 0.43) out of 7. The mean agreement of semantic relatedness was higher for unrelated words (96.3%) than related words (65.35%).

Discussion

Although gender information was unrelated to the task and participants were not directed to utilize gender as a tactic, an effect of grammatical gender was detected in Hindi speakers in the category membership judgement task. Categorisation of a pair of words was facilitated when they shared the same grammatical gender. The lack of a significant effect for semantic relatedness could be explained by the participants' lower rating of semantic relatedness. Perhaps the stimuli used in this study did not represent typically related items. The bias due to material selection could be eliminated by replicating this study with another set of stimuli which are rated for semantic relatedness prior to the experiment. This study used orthographic representations of words in Devanagari script, instead of pictures as stimuli. It is possible that since the words activated the lexical representations, as opposed to conceptual representations activated by pictures. The effect of type of stimuli presented in this effect could be tested through a modification of this task paradigm where images are used as stimuli. This study does not explore the mechanism of gender representations being activated in semantic tasks. This could be further explored through priming studies. Similarly, EEG-ERP studies could reveal real-time processing of grammatical gender during object categorisation (Boutonnet, et al. 2012). However, this study shows that a gender effect is present in native Hindi speakers during a non-linguistic task. If native speakers of a non-gendered language are given the same task, and no gender effects are observed, it could serve as evidence for linguistic relativity in Hindi speakers through grammatical gender.

**Effects of Emotion on language Code Switching in Bilinguals**

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Introduction

Language code switching (CS) is the alternative use of two or more languages in a single speech and is accompanied by switch cost, which is the time taken to switch between the languages in use. Switching from L2 to L1 invited more switch cost than switching from L1 to L2 (Meuter and Allport, 1999). Asymmetry in switching cost is observed because producing target language requires active inhibition of the non-target language, and switching to the previously inhibited language requires release of previously applied inhibition, which is accomplished by the engagement of domain general cognitive control (Green, 1998).

Previous studies on bilingualism and emotion have shown that L1 and L2 are differentially associated with emotions (Pavlenko,2008). L1 is considered more stronglyassociated with emotions as compared toL2 (Altarriba,2008; Dewaele, 2004; Pavlenko, 2008) as a result L2 is processed semantically but not effectively to the same extent as L1. Evidence has suggested that taboo words in L1 induce more anxiety than the same content in L2 (Gonzales - Reigosa, 1976). Previous research suggests that L1 is more emotionally arousing than L2.From the qualitative reports, it has been found that bilinguals switch to their native L1 for more intense emotion whereas switch to L2 for less intense emotion( Williams A,2019; Tiina M., 2007). Thus, bilingual's specific preference for language to express emotion can be viewedas amechanism to regulate intensityof emotion which takeplace through code switching. However, most ofthese findings come from qualitative and clinical reports,therefore it remains to be seen howcode-switching is linked with emotion in bilinguals. Aya Williams (2019), found dynamic associationbetween CS and facial behavior in a dyadic emotion - inducing puzzle box task (Eisenberg et al., 2001).It was found that participants code-switched more frequently when expressed negative facial expressions as compared to when they expressed positive facial emotion.Taking their findings further, present study aimed to investigate how positive and negative emotions affects switching cost in L1 to L2 and L2 to L1 directions. Previous studies on emotion show that negative emotion facilitates conflict resolution.Based on this it was predicted that negative emotion would facilitate cognitive control engaged duringlanguage control therefore the task irrelevant language representations would be inhibited to less extent hencereactivation of previously inhibited representation on the subsequent trial would be easier, that will be reflected as shorter latencies on switch trials than no switch trials.

Method

Participant:17 participants were recruited from University of Allahabad, with the Hindi - English bilingualism as inclusion criteria.The age range was18-25.(Mage = 21.5, SD =2.28).

Stimuli:The task included Emotional cues followed by a picture naming, after which participants had to provide feedback for the emotion cues. For emotional cues, we used the IAPS database and for the picture naming task we used Snodgrass and Vanderwart database.

The participants went through the proficiency testing for each language, with Hilex and Lextale, followed by profiling. The task began with participants getting familiar with the images used for picture naming.A trial in the task begins with the emotional cue followed by 3 picture naming images which were presented in either a blue or red frame and then feedback for the emotion cue.Pictures in the blue frame had to be named in L2 and those in red had to be named in L1.Non switch and switch trials were divided in a 70:30 ratio. There were 3 blocks each of 80 trials.The first block is a baseline, with no emotion cue and just the picture naming, the second and third blocks were a mix of emotion and neutral images.Emotional images were positive and negative, so if second block is positive plus neutral then the third block will be negative plus neutral, which was pseudo-randomized.

Results:

ANOVA on the naming latency with Emotion (positive, negative, neutral) X Trial type (No switching, Switching) X Language ( L1, L2) as within group factors. Significant effect of emotion ($F(3,48)=18.3$, $p<.01$) showing naming latencies were shorter for negative emotion as compared to positive emotion. The main effect of trial type ($F(1,16)=6.3$, $p<.02$ was found significant, showing higher naming latencies for switch trials than no switch trials. A significant interaction between emotion and trial type ($F(3,48)=8.8$, $p<.01$) showed shorter naming latencies for switch trials for positive emotions than for negative emotions. A three way interaction between emotion x language x trial type ( $F(3,48)=10.8$, $p<.001$) showed shorter latencies for both L1 and L2 switch trials in negative than positive emotion. L1 no-switch trials for negative emotion were significantly shorter than L1 no-switch trials in positive emotion. No difference in the L2 no-switch trials for positive and negative emotion was found.

Discussion:

Results show higher naming latencies for switch L1 trials than switch L2 trials, replicating previous studies showing asymmetry in switching cost for switching into L1 and L2, showing switching invites switch cost. Higher latencies for L1 shows that, being the dominant language it takes more time to be reactivated once inhibited. L2 on the other

the less dominant requires less time for reactivation. Present findings showed that emotion influences code-switching. It was found that naming latencies, for both L1 and L2, were shorter for negative emotion block than positive emotions. Furthermore, shorter naming latencies for no-switch trials in negative emotion showed that negative emotion modulated both switch and no switch trials. This showed negative emotions enhanced cognitive control (Birk et al.2011), which leads to shorter naming latencies during switching, thus confirming our hypothesis.

**Impact of Literacy on Cognitive Performance: A Study on Urban Population**

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Introduction

Literacy is viewed as a tool for identification, comprehension, interpretation, and communication in a world that is becoming increasingly digital, text-mediated, information-rich and rapidly changing1,2. Over the past centuries, global literacy rates have seen significant growth, with just 12% of the world's population being literate in 1820, to 86% by 20163. Nevertheless, one in every four individuals in India is illiterate4, despite the ability to speak more than one language. For instance, an illiterate in Goa is much more likely to know more than one language than an urban graduate from Rajasthan, or Bihar5.

The question then is, do multilingual illiterates possess similar cognitive abilities as their literate counterparts? Research on the effect of literacy on cognition has shown that literates perform better compared to illiterates on cognitive tasks measuring working memory, visuospatial abilities and executive functions6,7,8. Illiteracy is also associated with a higher risk of dementia due to reduced cognitive performance9, thus making it essential to comprehend the cognitive implications of literacy and illiteracy. Few studies exist that comprehensively address the specific cognitive domains of illiterates10,11 which leads to the need for such studies. This current study seeks to investigate the potential impact of literacy on non-linguistic executive function tasks, shedding light on this important aspect of cognitive performance.

Method

A total of 25 literates (12 female) and 23 illiterates (13 female) participants from in and around NIMHANS, residing in urban Bangalore were recruited for the present study. The participants selected for the study were between 45-65 years of age. Participants' socioeconomic status was determined using Kuppuswamy Scale, based on family's education, annual income and occupation levels12. Forty participants were from the Lower Middle and Upper Lower categories; 7 participants (literates) from the Upper Middle and 1 participant (illiterate) from the Lower SES category. The Addenbrooke's Cognitive Examination (ACE-III) questionnaire was administered to ensure that the participants did not have any cognitive impairments. We also administered the Language Usage Questionnaire (LUQ) to measure language use and exposure in different contexts. The performance of participants was compared on Posner cueing, Flanker and Go/No-Go tasks which measured orientation of attention, conflict resolution and response inhibition (Figure 1). The order of presentation of these three cognitive tasks was counterbalanced across the participants. Care was taken to ensure that the participants received enough practice before doing the actual experiment.

Results

For the Posner cueing task, a two-way mixed ANOVA indicated that literate group (M = 492.62 ms, SD = 93.18) were faster compared to the illiterate group (M = 557.44 ms, SD = 124.04). The main effect of trial type was present, with participants being faster on valid (M = 509.59 ms, SD = 112.62) compared to invalid trials (M = 583.95 ms, SD = 126.19). Also, the interaction between trial and group was present ($p = 0.03$).

On Flanker task, literate participants (M = 656.34 ms, SD = 101.87) were faster than illiterate participants (M = 954.11 ms, SD = 383.72). The two-way interaction between trial and group was significant ($p = 0.01$). However, there was no significant difference between the literate and illiterate participants on Flanker effect.

Literate participants (M = 454.59 ms, SD = 81.83) had faster RTs compared to illiterate participants (M = 522.87 ms, SD = 95.72) on the Go/No-Go task. Similar to the Flanker task, both groups did not differ on no-go error rates ($p = 0.88$) and go error rates ($p = 0.24$). Overall, literate participants had faster RTs than illiterate participants on all three tasks.

Discussion

The results suggest that literacy plays an important role in performance on cognitive tasks. Literate participants had faster RTs on all the cognitive tasks compared to illiterate participants. However, the absence of a group difference in the Flanker effect implies that both literate and illiterate groups possess comparable inhibitory control abilities, indicating that their cognitive processes related to interference management are similar. The differences in reaction time are more likely associated with variations in attentional processing speed, with literate individuals potentially processing visual information more quickly due to their experience with written language. Similarly, there was no group difference on no-go error rates, indicating that both the groups did not differ on inhibitory control. In general, illiterate participants reported trouble understanding arrows, especially the arrow direction and corresponding keyboard response. Hence, they needed more practice trials to understand the task. It was also observed that participants who did not use smartphones had much difficulty performing the task (16 illiterates). It is possible that the overall processing speed observed for literate participants may be influenced by their ability to use smartphones as no difference on cognitive control measure was observed. To see if it is indeed smartphone use that contributes to the increased processing speed, data from rural illiterate participants can provide some insights.

## Perceptual processing determines how emotional information influence response inhibition

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Processing visual information from scenes is a pivotal component of our daily existence. One way to attend relevant information is to look at the whole scene (global processing), while the other way is to look at smaller parts of scene (local processing). Existing research has posited that global perceptual processing is associated with positive emotion and local perceptual processing is associated with negative emotion (Srinivasan & Hanif, 2010; Srinivasan & Gupta, 2011). Conversely, response inhibition involves cancelling initially planned but inappropriate responses to current goals (Logan & Cowan, 1984). In laboratory settings, the stop-signal task is frequently employed to investigate response inhibition. Studies exploring the role of emotional information in response inhibition have generally yielded mixed results (Pessoa et al., 2012; William et al, 2020).

We posit that the variability in these results may arise from differential perceptual processing of emotional information during the task. If the processing of emotional information is enhanced/diminished by perceptual processing, and response inhibition is also attentional resources dependent, then emotional information and perceptual processing should interact, cumulatively affecting response inhibition. Notably, prior investigations did not systematically manipulate the perceptual processing of emotional information. For a comprehensive understanding, we integrated a global-local Navon task with a stop signal task. Additionally, we incorporated a 2AFC gender discrimination task and a surprise memory recognition task for faces previously appeared as stop signal, aiming to elucidate relationship between perceptual processing and emotional information, i.e., whether global and local perceptual processing indeed is indeed linked to happy and angry facial expressions, respectively.

Methods

Thirty volunteers (15 females), aged 18 to 27 years, participated in this experiment which comprised four distinct tasks. Task 1 was a combined global-local stop-signal paradigm (Figure 1). During each trial, following a fixation, a compound digit served as the go signal. Participants were instructed to press the left arrow key for digit 6 or the right arrow key for digit 9. These two digits could appear as either a big digit made of other irrelevant digits 8, prompting global processing, or as small digits making a big digit 8, prompting local processing. Digit 8 was irrelevant and always present. Stop signals, face images, were presented in 30% of total trials after go signal, and participants were instructed to not press a button. There were nine blocks. Each block had 52 trials. Stop signal reaction time (SSRT), calculated per Verbruggen et al. (2019), served as a metric of successful inhibition, with a higher SSRT indicating poor inhibition.

Task 1 was succeeded by two filler tasks, each lasting four minutes (Task 2 and Task 3). In surprise recognition paradigms, filler tasks introduce an encoding-retrieval delay and prevent elaborate rehearsal (Chiu & Egner, 2015). In Task 2, participants were asked to make quick gender discrimination of faces within a duration of 700 ms. Half of the faces were drawn from Task 1, while the remaining half consisted of new faces. Task 3 required participants to perform a go/nogo task, classifying even and odd numbers. Task 4 entailed a surprise memory recognition task involving faces previously encountered as stop signals in Task 1, intermixed with new faces. Successful recognition was quantified using d prime. 96 face images (48 identities, two emotions: angry, happy, 24 male, 24 female) from various databases were used. The old faces used in Task 2 and Task 4 were also different.

Results

In Task 1, the main effect of the perceptual processing on SSRT was not significant, $F(1, 26) = 0.21$, $p = .64$, $\eta p2 = 0.008$. The main effect of emotion was not significant, $F(1, 26) = 0.016$, $p = .9$, $\eta p2 < 0.001$. We found a crossover interaction effect of perceptual processing and emotion, $F(1, 26) = 10.77$, $p = .003$, $\eta p2 = 0.29$. Pairwise comparisons revealed that, under global perceptual processing, SSRTs were significantly higher for happy face expressions stop signal compared to angry face expressions (Figure 2), $t(26) = 2.23$, $p = .035$, $d = 0.42$. Consequently, the stop signal with irrelevant happy facial expressions impaired inhibitory control compared to irrelevant angry facial expressions under global perceptual processing. Under local perceptual processing, SSRTs were significantly lower for stop signal with irrelevant happy facial expressions compared to irrelevant angry, $t(26) = -2.51$, $p = .018$, $d = 0.45$, facial expressions. Thus, the happy stop signal significantly facilitated inhibitory control compared to angry under local perceptual processing.

Similarly, in Task 2, we found no main effect of perceptual processing and emotion on reaction time, however, a crossover interaction effect emerged. In sum, global-happy and local-angry faces, which previously appeared as stop signal, slowed down gender discrimination compared to global-angry and local-happy faces, respectively. Similarly, in Task 4, we found no main effect of perceptual processing and emotion ond prime, however, a crossover interaction effect emerged (Figure 3), indicating that happy faces as stop signal under global conditions and angry faces as stop signal under local conditions were processed in an enhanced manner.

Discussion

The primary objective of this study was to explore the interactive impact of perceptual processing (global vs. local) and irrelevant emotional information (happy vs. angry) on response inhibition. Our findings showed that, under global perceptual processing conditions, happy faces exerted a detrimental effect on response inhibition when compared to their angry counterparts. Conversely, under conditions of local perceptual processing, happy faces facilitated response inhibition relative to angry faces. Furthermore, in a surprise recognition task, we observed that happy faces associated with global condition are recognised better than angry faces associated with global condition. Conversely, angry faces associated with local condition were recognised better than happy faces associated with local condition. This suggests that enhanced processing of happy faces during global perceptual processing diverts attentional resources away from the inhibition process, ultimately impairing inhibitory control. Similarly, the enhanced processing of angry faces during local perceptual processing also diverts attentional resources away from the inhibition process, leading to a decrement in inhibitory control. These results shed light on the underlying reasons for the mixed findings in the existing literature on the role of emotional information in response inhibition. Moreover, they open up novel avenues for revisiting theories concerning the interplay between emotion and cognition.

**Irrelevant emotional expressions interfered with response inhibition: the role of contrast emotions**

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Introduction:
Previous studies examined the role of irrelevant emotional facial expressions in response inhibition. Irrelevant emotional faces would facilitate or inhibit response inhibition, depending on how these faces are paired with different emotional faces. In previous studies, angry faces were either paired with neutral, happy, or fearful faces in the response inhibition task, potentially leading to mixed results. Notably, in previous studies (Verbruggen & De Houwer, 2007; Pessoa et al., 2012), only two irrelevant emotions (happy vs angry; happy vs fearful; angry vs fearful; positive vs negative IAPS images) were used as stop signals (see Table 1), and mixed results were observed. Since motivational reactions (approach/avoidance) of emotional faces are influenced by the contrasting emotions presented in the task/experiment/block (Paulus & Wentura, 2016). Therefore, previous studies are only partially able to examine the role of irrelevant emotional information in response inhibition.

In the present study, instead of two, we simultaneously compared four irrelevant emotions (angry, fearful, happy, and neutral) in the same block to examine the role of irrelevant facial emotions in response inhibition. More specifically, to our knowledge, this is the first study that examined the differential effect of negative faces (angry and fearful) on response inhibition, where two irrelevant negative expressions (angry and fearful) were used as stop signals and simultaneously compared with irrelevant happy and neutral facial expressions. Since all four emotional faces are paired in the same block; therefore, it would be interesting to examine the motivational tendency (approach/avoidance) of which emotional face(s) would be changed. In other words, the design of the present study would help test the prediction of four frameworks ("arousal", "dual competition", "approach and avoidance" and "contrast emotions").

Methods:
Forty-two young adults (27 females, M = 27.47 years, SD = 3.71 years, age range = 20–37 years) participated after giving informed consent. We estimated (using G-Power) a necessary sample size of 29 to obtain a power level of 0.95 given an effect size ($\eta p2 = 0.074$) for the main effect of emotions that was derived from a previous study using the same SSRT measure and a similar task setup (Gupta & Singh, 2021). The stop-signal paradigm was used in the present study. There were two types of trials: go- and stop-trials. Participants were required to respond to the go signals (discriminate between X and O). Occasionally, a stop signal with irrelevant facial expressions (happy, angry, fearful, or neutral) was presented, where participants were required to withhold their motor response (see Figure 1).

Results:
Stop signal reaction time (SSRT) was calculated for the four types of stop signals, providing an estimate of the inhibitory reaction time (Pessoa et al., 2012). SSRT is the time required for successful inhibition (Kalanthroff et al., 2013). The SSRT value was computed by subtracting the average RT during the correct go trials from the average SSD (SSD values: happy: M = 297.6, ms, SD = 36.37 ms; angry: M = 291.2 ms, SD = 48.55 ms; fear: M = 289.9 ms, SD = 31.54 ms; neutral: M = 300.01, SD = 39.05 ms) (Logan & Cowan, 1984; Verbruggen & Logan, 2009). SSD was adjusted using a stair casing method for each type of stop signal (neutral, happy, angry, and fearful) to obtain approximately 50% accuracy for inhibition. A one-way repeated measure ANOVA was performed on the SRRT values using the stop signal type (happy, angry, fearful and neutral) as a within-group factor. The alpha level was set to 0.05 (Uncorrected).

A one-way ANOVA of the SRRT score revealed a significant main effect of the stop signal type, $F(3, 120) = 4.11$, MSE = 684.99, $p = 0.008$, $\eta 2p = .093$, which suggests that irrelevant emotional information modulates response inhibition (see Figure 2). The SSRT score was significantly higher for angry (M = 340.20 ms, SD = 61.54 ms; $t(40) = 2.52$, $p = 0.016$), happy (M = 335.61, ms, SD = 62.12 ms; $t(40) = 2.41$, $p = 0.02$), fearful face stop signals (M = 333.32, SD = 53.26; $t(40) = -2.02$, $p = 0.049$) compared to the neutral stop signal (M = 320.82, SD = 61.61 ms). This indicates that stop signals with irrelevant angry, fearful, and happy facial expressions interfered with response inhibition. The SSRT score was comparable for angry, fearful and happy stop signals ($p > 0.05$ for all).

Discussion:
Our results extend previous findings by suggesting that approach and avoidance reactions to facial expressions depend on the contrasting emotions presented in the task. The finding helps explain many inconsistent results with respect to the effect of emotions on response inhibition reported in the literature. These results have theoretical implications for understanding the nature of emotions and their interaction with cognitive control functions. The results of the present study indicate that stop signals with irrelevant angry, fearful, and happy facial expressions interfered with response inhibition compared to stop signals with irrelevant neutral facial expressions. These results have several theoretical implications. First, our results extend previous findings by suggesting that approach and avoidance reactions to facial expressions depend on the contrasting emotions presented in the task. Second, it provides insight into the nature of irrelevant emotional information in cognitive control functions. Third, it also suggests that the role of valence (emotional vs nonemotional) needs to be considered in determining inhibitory control. Fourth, the finding also helps explain

inconsistent results with respect to the effect of emotions on response inhibition reported in the literature. The findings of the present study also have practical implications. For example, the current result indicates that compared to non-emotional information, emotional information interferes with response inhibition. For example, if you want your child to stop unacceptable behaviour, the best way to give them a warning (e.g. you will put him or her in time-out if the behaviour does not stop) while maintaining calmness on the face (i.e. without showing facial expressions of anger or happiness). Neutral facial expressions may facilitate controlling their unacceptable behaviour.

## Effect of Creative Cognitive Reappraisal on Extinction of conditioned responses

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Introduction:
Extinction has been used to reduce fear, although it works to achieve the reduction in the form of reduced behavioural expectancy, for some people it later results in fear relapse. The reason could be that extinction works on reducing the expectation of the unconditioned stimulus (UCS) after the presentation of the conditioned stimulus (CS+), and not the negative valence associated with the CS+. Therefore, the negative valence associated with the CS+ could result in the relapse even after successful extinction. Cognitive reappraisal is an emotion regulation technique which involves changing the way or reinterpreting how a person thinks about an emotional event or stimulus. Cognitive reappraisal can be used to change the valence associated with the CS+. Apart from learning to expect the UCS after the CS+, the CS+ also acquires a negative valence which is difficult to resolve through extinction. Studies have also shown a positive relationship between degree of negative valence to CS+ after performing extinction and subjective fear ratings after reinstatement (Zbozinek et al., 2015). Literature has also suggested that negative valence associated with CS+ after extinction leads to avoidance which interferes with the strengthening of the CS-no UCS inhibitory association (Dour, Brown & Craske, 2016). Literature shows negative valence associated with CS+ even after extinction (Kang et al., 2018) could be the reason of reappearance of conditional responding.
The current study was designed to investigate the effect of cognitive reappraisal on valence and compare the effect of creative, ordinary reappraisal and standard extinction.

Methods:
We used the Screaming Lady paradigm (Lau et al., 2009). We followed a three-day fear conditioning paradigm with 27 participants (Males=20, Females=7). Habituation and Acquisition took place on day 1 with 4 and 16 trials of each CS. Extinction took place on day 2 with 12 trials of each CS. Extinction recall took place on day 3 with 6 trials of each CS. The experiment consisted of three groups: Creative cognitive reappraisal & standard extinction, ordinary cognitive reappraisal & standard extinction and standard extinction only group. All the groups followed the same procedure except for day 2, in creative cognitive reappraisal and ordinary reappraisal group participants were provided a creative reappraisal and ordinary reappraisal sentence respectively and cued to think about it when they saw the CS+ during extinction protocol the participants rated on measures of valence, arousal and fear after each phase and online expectancy in each phase.
Selection of face stimuli:
For selection of the stimuli to be used in the experiment we decided to take fear emotion pictures from two databases: NimStim and CBCS and asked a group of participants to rate the faces on three scales: Fear, Arousal and Valence. We asked a group of 15 participants (Males= 6 & Females= 9) with mean age of 21.3 years to rate the faces. After the analysis of the data, we selected two female model faces from the NimStim Face stimuli database.
Generation and selection of Cognitive reappraisal sentences:
For generation of cognitive reappraisal sentences we asked a group of 5 creative students (Mean age: 19.4 years) who were interested in the experiment to generate new interpretations for the unpleasant UCS, with the aim of reducing unpleasant feelings that arose from the stimuli. The cognitive and the ordinary reappraisal sentences were evaluated on creativeness, effectiveness and appropriateness on a 9-point Likert scale. We conducted a pairwise t-test to check if the creative and ordinary cognitive reappraisals differed on the three criteria of evaluation. The test showed that creative cognitive reappraisal and ordinary cognitive reappraisal differed significantly on creativeness $t(14) = -2.560$, $p = .023$ and not on effectiveness $t(14) = .094$, $p = .927$ and appropriateness $t(14) = -.218$, $p = .830$ of the sentences. We selected one sentence for both creative and ordinary reappraisal.

Result:
We performed a one-way ANOVA to check the difference in the means of the groups across four phases. We found a marginally significant difference at between groups in the extinction recall phase $F(2,24) = 3.1$, $p = 0.63$, $\eta 2 = .20$. LSD post hoc test results revealed that the creative cognitive reappraisal group had significantly higher valence recall $p = .029$, 95% CI [.22, 3.77] ($M = .11$, $SD = 2.08$) compared to the ordinary reappraisal ($M = -1.8$, $SD = 1.36$) and a marginally significant $p = .065$, 95% CI [-0.10, 3.44] higher valence recall than standard extinction group ($M = -1.5$, $SD = 1.94$) There was no significant difference in valence recall between the ordinary reappraisal group and standard extinction group. Due to the less sample size, we could not report the Bonferroni values. The LSD values were not corrected for multiple comparison and from the results we expect 5% of the comparisons to have uncorrected P values less than 0.05.

Discussion
Our results hint that for participants in creative cognitive reappraisal the valence for the CS+ had increased and exhibited a better recall of higher valence than ordinary reappraisal group and standard extinction group in the extinction recall phase. Although we didn't see any significant difference in valence in the extinction phase itself, it could be that creative cognitive reappraisals forms a new and novel representation or in other words updates the UCS mental representation (

Wang, 2022) during the extinction phase and leads to more positive valence recall on the third day. The insignificant difference between the groups during the extinction phase could be due the effect of similar extinction protocol being followed in all the three groups that could have overshadowed the effect of reappraisal.
For future studies and discussion, we will be incorporating and reporting physiological measures of fear as well for a better picture of reduction in fear responses through creative cognitive reappraisal. We will also increase the sample size for the experiment for better results and power.

**Emotion Modulates Age-Differences In Cognitive Flexibility**

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Introduction

Aging is associated with physical and cognitive decline but emotional aging appears to benefit from age. According to Socioemotional Selectivity Theory, advancing age is associated with limited lifetime, therefore older adults prioritize social and emotional goals related to optimization of immediate affective well-being over long term goals (Carstensen et.al., 2006).Hence, high levels of affective well-being and emotional stability are evidenced in old age due to shift in cognitive processing of emotional stimuli (Scheibe & Carstensen, 2010). Theories of emotional aging postulate changes in emotional goals with age with relative preference for positive over negative stimuli demonstrating the positivity effect (Carstensen et.al., 2005). Positivity effect reflects motivated cognition for emotion regulation. More cognitive resources in older adults seem to facilitate their ability to selectively attend to positive stimuli and avoid negative ones. Kennedy et.al. (2020) have shown preserved preference for emotional goals as well as prioritization for positive information in early stages of attention and memory among older adults. However, most of the previous work has not examined emotional aging across the life span nor has examined the effect of emotional stimuli on complex cognitive processes such as set-shifting. Therefore, the current study examined the effect of task irrelevant emotional stimuli (positive, negative, neutral) on task switching performance across young, middle aged and older adults. We hypothesized that the shift in emotional goals with increasing age would modulate the performance on task switching.

Methods

A total of 69 participants were recruited for the study. Young adults (Age 18-35 years, N=21), middle-aged (Age 35-55 years, N=25) and older adults (Age 55-75 years, N=23) were volunteers from Allahabad. A detailed cognitive profiling was conducted to screen the participants for mild cognitive impairment and dementia. All participants completed two experiments. Cued task-switching paradigm was used. The first experiment was a colour-shape switching task for calculating baseline switch costs for all the three age groups. The second experiment was a colour-shape switching with task-irrelevant emotional stimuli presented prior to the cue. The emotional stimuli were IAPS (positive, negative and neutral) images which were also rated by old-age participants. Task cue was either a shape or a colour stimulus. Target stimuli were square or circle in blue or red colour. There were 80 trials in each experiment with a 50:50 (high monitoring condition) proportion of switch and repeat trials.

Results

Mean age for young, middle and old adults were 23 years, 46 years and 61 years respectively. Overall accuracy for young, middle and old age adults were 89%, 87.22 % and 86.58% respectively in the baseline switching task. All RTs were log transformed considering high variance across participants of all the three age groups. Trial type[$F(1,72)=109.90$, $p<0.001$, $\eta 2p=0.604$] and Age [$F(2,71)=4.458$, $p=0.015$, $\eta 2p=0.11$] significantly affected the RTs. The baseline switch costs were higher for middle-age group compared to young and were comparable with old age participants. Overall accuracy for young, middle and old age adults were 92.83%, 93.30% and 86.16% respectively in the switching task with emotions. A repeated measures ANOVA was performed with age group (young, middle, old) * trial type (switch, no-switch) * emotion (positive, negative, neutral). Overall switch trials were slower than repeat trial, [$F(1,72)=120.38$, $p<0.001$, $\eta 2p=0.646$]. Interaction between trial type and emotion [$F(1,72)=8.509$, $p<0.001$, $\eta 2p=0.114$] is significant.Three way interaction was found between Trial type, Emotion and Age [$F(4,68)=4.056$, $p=0.004$, $\eta 2p=0.109$].Post hoc comparisons yielded a significant difference between switch and no-switch condition in the trials with positive emotions for young and middle-aged adults. There was a significant difference between switch and no-switch condition in the trials with negative emotions for young and middle-aged adults. Older adults showed a significant difference in switch and no-switch condition for trials with neutral stimuli ($p= .004$). Remaining post-hoc comparisons were not significant. Planned comparisons showed less switch cost for positive, negative and neutral condition (all ps $<0.05$) for older adults than young adults. Also, there was no difference in the positive and neutral switch costs for older adults. The switch costs for baseline task were lesser compared to the switch task with emotional stimuli for the middle and older adults whereas they were comparable in case of young adults.

Discussion

The baseline switch costs were higher for middle age group compared to young adults. However, switch costs for older adults were comparable to young and middle-aged adults suggesting no significant decline in set-shifting in older adults. The second experiment examined how positive and negative emotions modulate task switching across young, middle-aged and older adults. In the old age group, significant effect in trials with neutral stimuli and no difference in trials with positive or negative emotion shows that emotional information facilitated switch performance in the elderly. Their slower reaction times and higher switch costs in positive emotion trials (than negative) indicates that older adults may process positive information more and find it difficult to disengage from the same to enable switch performance in the subsequent trial. Also,

switch costs in case of task irrelevant emotional stimuli are lower than the baseline switch costs for middle-aged and older adults, which indicates that task-irrelevant emotional stimuli facilitated their switch performance. This finding suggests prioritization of emotional stimuli with age, even when they are task-irrelevant. Higher switch costs for positive and lower switch costs for negative stimuli suggest greater engagement with positive and faster disengagement from negative stimuli with increasing age. Future work may explore the effect of emotional valence on attentional disengagement with task irrelevant emotional stimuli across the life span.

# Resting state functional brain correlates of behavioural manifestations in Autism Spectrum Disorder

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Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder affecting multiple cognitive domains, thereby resulting in aberrant cognition. These atypical behaviours pose various challenges to daily life in ASD. Adults with ASD and the role of comorbidities in modulating functional connectivity has relatively been overlooked. Given its neurodevelopmental nature and the high prevalence of psychiatric comorbidities1 (depression) in this population, investigating the functional connectivity in the adult ASD brain is therefore of relevance. We explored the differences of seed-to-voxel, resting state functional connectivity (rsfc) within the brain of individuals with ASD and those typically developed (TD), independently and in association with the severity of the psychiatric comorbidity of depression using functional magnetic resonance imaging (fMRI) datasets from the Autism Brain Imaging Data Exchange2 (ABIDE-II) repository. Further, the association of the rsfc was studied with the severity of the clinical symptomatology in ASD and its interaction with the severity of depression. The results attempt mechanistic explanations of the adult ASD phenotype highlighting differential functional connectivity of seeds identified in a few key biological neural networks of ASD3, i.e., the default mode network, affective salience network, and fronto-parietal network, with different regions of the brain offering insights for future research.

Method

Participants (18-35 years) with ADOS, BDI4 (Beck's Depression Inventory), and FIQ5 (Full Scale IQ) scores were classified into individuals with ASD and TD groups. We reached a final sample size of 44 individuals with ASD (mean ± SD: age = 21.34 ± 3.07, ADOS=9.88 ± 2.8, FIQ = 110.5 ± 15.27, BDI = 11.78 ± 9.8; 4 females) and 35 TD individuals (mean ± SD: age = 24.02 ± 3.62; ADOS=2.11 ± 1.4, FIQ = 111.2 ± 12.84, BDI = 4.6 ± 5.12; 15 females). Scanning site, mean framewise displacement, FIQ and age were controlled for as default nuisance covariates. The group-level analysis employed a voxel-level threshold of $p < 0.005$ and a cluster-level threshold of $p < 0.05$, family-wise-error (false discovery rate) corrected for multiple comparisons. Standard preprocessing pipeline of the CONN toolbox6 (MATLAB 2022a) was used. Denoised and pre-processed time series were extracted from the brain regions of a priori interest as seeds and seed-based-connectivity maps (computed as Fisher transformed bi-variate correlation coefficients between seeds and all other voxels) plotted.

Results

The first group-level analysis revealed hyper-connectivity in ASD vs. TD between bilateral Caudate seed and clusters in Insula, Frontal, Occipital lobes; seed Insula and clusters in Occipital, Parietal lobes, bilateral Caudate; Anterior Cingulate Cortex (ACC) seed and Caudate Right; and Amygdala seed and Caudate Right cluster (all $p < 0.05$, all kE ≥ 314 voxels, all effect size beta ≥ 4.10). By contrast a few seeds were hypo-connected with some clusters in ASD than TD - Caudate; Precuneous; Insula and ACC seeds and clusters in Cerebellum, Temporal, Paracingulate Gyrus, Frontal lobes and Caudate Left respectively (all $p < 0.05$, all kE ≥ 401, all effect size beta ≥ 4.54). The effect of depression was tested which revealed BDI positively modulated the hyper-connectivity in ASD compared to TD between Angular Gyrus and Insula seeds and clusters in Occipital lobe and Cerebellum respectively (all $p < 0.05$, all kE ≥ 473 voxels, all effect size beta ≥ 4.33) and negatively modulated the hypoconnectivity– between the seed Amygdala and cluster in Parietal lobe ($p < 0.01$, kE= 968 voxels, effect size beta = 4.64). A positive correlation was found for the effect of ADOS in ASD connectivity between Insula seed and clusters in Occipital lobe; Insula and Caudate seeds and cluster in Frontal lobe; Frontal Pole seed and cluster in Occipital and Frontal lobes (all $p < 0.05$, all kE ≥ 315 voxels, all effect size beta ≥ 4.39) and a negative relationship with seeds-Insula seed and cluster in Frontal lobe; Posterior cingulate cortex (PCC) seed and cluster in Temporal lobe; Caudate seed with clusters in Parietal and Frontal lobes; and ACC and Cerebellum ( all $p < 0.01$, all kE ≥ 339, effect size beta ≥ 4.3 ). The interaction between the clinical severity and depression was analysed using multiple linear regression. The data was split by the median ADOS score (9.5) - mild (mean ± SD: 7.5 ± 1.37) and severe (mean ± SD: 12.18 ± 2.06). The results revealed that depression modulates the connectivity between seed Medial prefrontal cortex (MPFC) with Cerebellum 6 Left ( $p < 0.01$, kE=443, effect size beta =4.99); Lateral prefrontal cortex Left (LPFC l) seed with cluster Precentral Gyrus Left ($p < 0.05$, kE = 433, effect size beta =4.84); Lateral prefrontal cortex Right (LPFC r) with three clusters- Postcentral Gyrus Left, Supramarginal Gyrus posterior division Left or pSMG l, Supramarginal Gyrus anterior division Right or aSMG r ( all $p < 0.05$, all kE ≥ 309, effect size beta ≥ 4.57) differentially in the two subsets of ASD adults. Increasing depression severity in the ASD adult subset with milder clinical severity decreases the rsfc whereas increases the rsfc with more clinical severity between the aforementioned seeds and voxels. The pattern was similar across all the aforesaid brain regions.

Discussion

While the hyperconnectivity between the Insula seed and clusters in the Occipital lobe could explain the feature of atypical selective attention paid to objects7, the hyperconnectivity between Insula and Caudate seeds and clusters in the Frontal lobe may explain atypical motor functioning. A similar trend was observed between the Frontal Pole seed and cluster in the Frontal lobes which may be associated with an aberrant reward value system and prevalence of circumscribed interests among ASD individuals. The increased connectivity between the Frontal Pole seed and cluster in the Occipital lobes could be associated with a preference for non-social rewards, and between the Caudate seed and cluster in the Frontal lobe could explain atypical motor functioning, as well as social and communicative impairments. A negative relationship between the seed Insula and cluster in the Frontal lobe may explain the atypical characteristics of motivation, reward and movement. The reduced connectivity between the PCC seed and cluster in the Temporal lobe could be associated with general reading and language impairments14. The decreased connectivity between Caudate seed and clusters in the Parietal lobes may point to alterations in visual perception and mental imagery that occur among ASD individuals and between Caudate seed and cluster in Frontal lobe may be associated with stereotyped behaviour in autism8 and between ACC and Cerebellum could be associated with impaired emotion regulation.

Our findings showed that with increasing severity of depression, the hyperconnectivity between the angular gyrus and lateral occipital cortical regions also agrees with previous findings for its role in the pathophysiology of depression. Hyperconnectivity was also observed between the Insula and Cerebellum since the Cerebellum is also involved in emotion and cognition18. The hypoconnectivity between the amygdala and cluster in the Parietal lobe with increasing severity of depression could explain the altered self-representation.

The interaction between clinical severity and depression positively modulated connectivity between MPFC and Cerebellum. These results could explain the impaired mentalisation and emotional regulation among ASD individuals. The hyperconnectivity between LPFC and the Precentral gyrus may explain the social and motor impairments, and between LPFC and the Postcentral gyrus may explain the deficits in body and emotional processing. Finally, the interaction also positively modulated the connectivity between the right LPFC and SMG, which could be due to the role of the superior parietal lobule that plays an essential role in motor learning in ASD.

The analyses aimed to elucidate rsfc differences between ASD and TD per se and in association with the depression severity, focussed on examining the relationship of the clinical severity of ASD with intrinsic functional connectivity, and the modulation of this relationship by the severity of comorbid depression. Consequently, our analyses revealed differential intrinsic functional connectivity between ASD and their TD peers and clarified the role of the severity of core ASD features and its interaction with the severity of comorbid depression respectively with rsfc in ASD. These results are of importance to develop an understanding of the ASD phenotype in terms of resting state functional brain networks towards its effective management.

**Association between depression and cognitive impairment in an aging rural Indian population**

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Introduction

Depression is a complex neuropsychiatric disorder and a prime contributor to the global burden of illness [1]. Nearly 3.8% of the population lives through depression and this number increases to 5.7% among older adults [2]. Older adults are more vulnerable because of life events, reduced mobility, and social isolation [3]. Cognitive impairment refers to deterioration in one or more cognitive functions of the brain like learning, memory, attention, and decision-making. It can extend from mild to severe, with severe impairment that hinders daily activities and self-reliance generally termed as dementia [4]. Depression and cognitive impairment are common mental health issues among older adults [5]. Multiple studies [6, 7] have shown that cognitive impairment is more frequently noticed in older adults with depression compared to the older adults without depression. Also, it has been observed that older adults residing in rural areas with depression experience a higher occurrence of cognitive impairment as compared to their counterparts residing in urban areas. In India, particularly in rural contexts where illiteracy remains at an alarming rate, the association between depression and cognitive impairment is still not understood broadly [8]. Therefore, it is essential to estimate the association between depression and cognitive impairment, particularly among elderly population living in rural areas of India. So, we aimed to estimate the association between depression and cognitive impairment in an aging rural population, in the state of Karnataka, India.

Methods

A cross-sectional study included 4,477 participants of age group ≥45 years from the Srinivaspura Aging, Neuro Senescence and COGnition (SANSCOG) study, an ongoing prospective, population-based cohort study in rural India. Participants were recruited through an area sampling strategy, from villages of Srinivaspura, Kolar district, Karnataka state, India. The Geriatric Depression Scale (GDS-30) questionnaire was used as a screening tool for depression and used a cut-off score of 10 and above for diagnosis of depression [9]. The Clinical Dementia Rating (CDR) was used to assess cognitive impairment. All healthy controls had a CDR score of 0 and all mild cognitive impairment (MCI) participants had a CDR score of 0.5 [10]. Participants with CDR score greater than 0.5 were excluded as our study cohort included dementia-free participants. The logistic regression model was used to find the association between depression and MCI. We built two models. Model 1 was unadjusted and model 2 was adjusted for age, gender, interaction of age with depression, and interaction of gender with depression. P-value<0.05 was considered to be statistically significant in all the analyses. All analyses were performed using Stata 18.0.

Results

The prevalence of MCI in our sample was 8.06%. The unadjusted logistic regression (model 1) showed that people with depression had 2.57 times higher odds of MCI compared to people without depression (95% CI:2.01,3.29, P-value<0.05) and further after adjusting for other covariates (model 2) the association persisted with depressed people had 2.98 times higher odds of MCI compared to non-depressed people (95% CI:1.56,5.69, P-value<0.05). However, there was no significant interaction between age and depression on MCI, and also interaction effect between gender and depression was also not significant on MCI.

Discussion

Our study findings imply that depression is associated with poor cognition and is a potential risk factor for developing cognitive impairment. Our study had several strengths including a large sample size and utilization of standardized tools like GDS and CDR. Limitations include the cross-sectional nature of the data. In the future, we intend to do a longitudinal follow-up of these participants which will help us to estimate the degree of risk of depression for MCI.

## Medial prefrontal morphology in schizophrenia: Clinical and cognitive correlates of variations in Paracingulate sulcus

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Introduction:
The functional and morphological variations in the medial prefrontal cortex (mPFC) have been able to predict variance in "reality monitoring" in healthy subjects.1 The inability to judge the source of cognitive faculties as internal or external is thought to be a core mechanism underlying schizophrenia. Delusions and hallucinations, the core psychotic symptoms, are characterized by beliefs and perceptions with an inability to discriminate them to be imagined and real. Hence, morphological variations in mPFC could play a role in the pathogenesis of schizophrenia.
The higher fissurisation in the brain is reflective of finer cognitive abilities.2 The paracingulate sulcus (PCS) is evolutionarily newer, appears in the later stages of embryonic life, and varies widely in its presence and length across human beings.1 Heterogeneity in PCS length is posited to have a pathophysiological role in schizophrenia.
Hence, we aimed to evaluate the PCS length using structural magnetic resonance images (MRI) in patients with schizophrenia with individuals genetically at risk for schizophrenia and healthy individuals. Additionally, we aimed to examine the clinical and cognitive correlates of PCS length in patients with schizophrenia.

Methods:
Clinical data and T1w MRI data from a 3Tesla scanner of 124 right-handed drug naïve/free schizophrenia patients, 91 first-degree relatives of patients with schizophrenia (FDRs), and 230 healthy controls aged within 18-45 years of either sex were used in the study after obtaining approval from the institutional ethics committee. Those unwilling to consent, uncooperative, having other psychiatric or any major neurological/medical conditions were excluded from the study. Comprehensive clinical evaluation included a rating of symptoms using the Scale for assessment of positive and negative symptoms (SAPS and SANS) and a battery of cognitive tests. A standard manual morphometric procedure2,4 was followed using MANGO© software5 after ascertaining a good (ICC>0.85) interrater reliability among the two raters. The differences in the PCS lengths across the three groups were compared using Analysis of Variance (ANOVA) and Repeated measures ANOVA (RMANOVA); correlation with clinical symptoms and neurocognitive functions was explored using Pearson's correlation.

Results:
One-way ANOVA showed significant differences in the mean length of PCS ($F=3.66$, $p=0.03$, $\eta p2=0.02$), with post-hoc Tukey showing patients with schizophrenia having shorter PCS (Cohen's $d=0.29$) compared to HCs. The mean PCS length of FDRs was higher than schizophrenia ($d=0.07$) but lower than HC ($d=0.19$). This group effect did not survive ($F=1.26$, $p=0.28$) when the total intracranial volume, age, and sex of the subjects were used as covariates. Though a hemisphere effect was noted (Left PCS>Right PCS, $F=25.98$, $p<0.001$, $\eta p2=0.06$) in RMANOVA, it was not statistically different across the three groups. Lesser leftward asymmetry correlated ($r=0.19$, $p=0.04$) with a higher positive symptom severity score. The formal thought disorder ($r=0.22$, $p=0.01$) and delusion ($r=0.19$, $p=0.01$) subdomain scores but not hallucinations ($r=0.005$, $p=0.94$) showed a similar trend in correlation with loss of asymmetry. In addition, the leftward laterality positively correlated with working memory function (digit-span backward: $r=0.21$, $p=0.02$ and letter-number sequencing test: $r=0.22$, $p=0.04$). The digit-span forward ($r=0.19$, $p=04$) and spatial-span backward ($r=0.2$, $p=0.04$) correlated with total PCS lengths.

Discussion:
This is one of the largest studies evaluating the PCS in schizophrenia, and we could note a significantly smaller PCS length in schizophrenia. 3,4,6 Earlier studies had shown a significant relationship of hallucinations with shorter PCS,2,3 but we could not confirm the same in our study. This may be due to a smaller proportion of patients who did not have hallucinations. However, the correlations between delusions and formal thought disorder suggest that the shorter PCS may not be specific to hallucinations but to positive symptoms. Though not statistically different, individuals at risk for schizophrenia had mean PCS between patients and healthy individuals, suggesting the possibility of it being an endophenotype marker.
Our observation of the leftward asymmetry of PCG replicated the earlier findings in healthy subjects and was noted in all three groups.7 A better asymmetry was associated with lower positive symptom severity and better working memory functioning in schizophrenia patients. This adds to the evidence of reduced hemispheric asymmetry in schizophrenia. Reduced gyrification during the developmental process may lead to cognitive impairments predisposing individuals to schizophrenia. Overall, the study findings support the importance of mPFC morphology in the pathophysiology of schizophrenia.

**Association between Anemia and Cognition in community-dwelling rural cohort: SANSCOG study**

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INTRODUCTION

Anemia is an associated as significant health risk factor for developing dementia in elderly population (Dlugaj et al., 2016; Hong et al., 2013; Kim et al., 2019; Weiss et al., 2022).The burden of anemia cases in elderly population will likely to increase in near future and potentially contributing to brain disorders. Hence, it is crucial to understand the relationship between anemia and cognitive impairment.

The current study aims to examine the association between anemia and global cognitive function on community-dwelling rural Indian cohort aged 45 years or older having comprehensive clinical, neurocognitive and blood biochemistry assessment.

METHODS

SANSCOG is an ongoing longitudinal, community-based rural study in India with a long-term follow-up period for 10,000 participants. All the participants have undergone comprehensive clinical, neurocognitive, genetics, neuroimaging, and biochemical assessments at the time of enrollment in the study. In this study, 4404 baseline subjects have been included and data was collected between January 2018 to November 2022.

Anemia was defined according to World Health Organization (WHO) criteria; hemoglobin concentrations lower than 13 mg/dL for men and lower than 12 mg/dL for women. In this study, sex-stratified hemoglobin concentrations were used to obtain two categorical variables indicating status of anemia; anemic and non-anemic (at the time of study). To measure cognitive performance, Hindi-Mental State Examination (HMSE) scores were used which measures global cognition which is adapted for rural Indian cohort.

For statistical model, the outcome/exposure variable was status HMSE score (continuous, range: 0-31) and the predictor variable was status of anemia (categorical; anemic or non-anemic). The covariates used in this study includes age (continuous; years), gender (categorical; male and female), education (continuous, years), Kuppuswamy score (categorical; lower, middle, upper), depression (categorical; depressive, non-depressive), smoker (categorical; smoker, non-smoker), alcoholic (categorical; alcoholic, non-alcoholic), diabetes (categorical; diabetic, non-diabetic), hypertension (categorical; hypertensive, non-hypertensive) and BMI (continuous).

RESULTS

We excluded subjects with 229 missing education data, 10 missing smoker data, 22 missing alcohol consumption data, 74 missing BMI data, 400 missing depression assessment data, 408 missing HMSE assessment data, 2 missing hemoglobin data, and 21 subjects with elevated hemoglobin measurements, leaving a total of 3722 participants.

The analysis was done on 3722 participants having mean age of 59 years and consisting of 1943 (52%) females and 1779 (48%) males. Out of 3722 subjects, anemia was diagnosed in 859 subjects of which 555 (65%) were female and 304 (35%) were male. In unadjusted linear regression model, significant association was found between anemia and HMSE score ($\beta$ = -0.72, 95% CI: [-0.94 -0.50], $p < 0.001$), indicating that anemic subjects have lower global cognitive score than non-anemic subjects. After adjusting for age and gender (Model 2), education years and SES (Model 3), depression (Model 4), and cardiovascular risk-factors (Model 5 – fully adjusted for all previously mentioned variables), association between anemia and HMSE score remained significant ($\beta$ = -0.23, 95% CI: [-0.44 -0.07], $p = 0.007$).

DISCUSSION

The study examined the association of anemia with global cognitive performance in community-dwelling rural cohort with mean age of 59 years and 23% prevalence of anemia. In both unadjusted and adjusted linear regression analysis, anemia was significantly associated with global cognitive performance (HMSE score). We observed that both anemics and non-anemics had mean HMSE score above the cut-off value for cognitive impairment of 23 (Tsolaki et al., 2000). However, after adjusting for all covariates, the best model (Model 5, based on AIC), the anemics had significantly lower HMSE score than non-anemics. Although the absolute difference in HMSE score between two groups was minimum, it is worthwhile to note that the small difference in HMSE score between anemics and non-anemics could be attributed to the extent of cognitive impairment in rural community-dwelling participants.

The strengths of our study include the large sample size consisting of rural community-dwelling subjects aged 45 years and above, and establishing the association between anemia and global cognitive performance. The limitations of our study are as follows: (I) Domain-specific neurocognitive assessment scores (e.g., memory, attention, executive functions, etc.) could not be used in this study as more than ten percent of the data showed irregularities or were missing in each domain, (II) sub-categorizing anemia based on mean corpuscular volume (MCV) and mean corpuscular hemoglobin (MCH) could help gain more insights into association of severity of anemia with cognition, (III) Cross-sectional nature of our study could not establish the causal relationship between anemia and cognition, (IV) No information available on medication or supplements taken by subjects. The early diagnosis and treatment of anemia could potentially lower the risk of dementia.

## The Individualized Music Program for the people living with Dementia in India: a feasibility study

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Introduction:
Recent advancement in music-based non-pharmacological interventions has demonstrated to have positive effects on the overall quality of life in persons living with dementia (Bakerjian et al., 2020; Leggieri et al., 2006; Schroeder et al., 2018; Thomas et al., 2017). MUSIC & MEMORY® is a USA based organization that helps individuals with cognitive and physical conditions to deal with their impairment through the use of personalized music playlist (Music and Memory Report, 2018). The organization is helping a wide range of populations suffering from dementia in the USA (Bakerjian et al., 2020; Leggieri et al., 2006; Music and Memory Report, 2018; Schroeder et al., 2018). The idea is that emotional connections associated with music will aid the recall of memories that were formed before the dementia set in (Bakerjian et al., 2020; Leggieri et al., 2006; Schroeder et al., 2018; Vinoo et al., 2017). Within the USA, the program has helped more than 1000 people to reduce their dementia-based depression through the individualized music program (Bakerjian et al., 2020; Schroeder et al., 2018; Thomas et al., 2017; Vinoo et al., 2017). The objective of this presentation is to demonstrate the feasibility of an adapted version of the individualized music program for the people living with dementia in India.

Methods:
In the initial stage, we adapted the music assessment questionnaire and playlist impact assessment questionnaire available from the USA-based MUSIC & MEMORY® program and modified them for the respective Indian versions which was further accepted and authorized by the MUSIC & MEMORY® organization team for the research purpose. So far we have recruited 19clinically diagnosed dementia patients from 8 states (Assam, Bihar, Karnataka, Kerala, Manipur, Rajasthan, Tamil Nadu, West Bengal) of Indiaand performed different cognitive assessments through the Addenbrooke's Cognitive Examination-III (ACE-III), Clinical Dementia Rating (CDR)Scale, Cornell Scale of Depression in Dementia (CSDD) and Geriatric Depression Scale (GDS). The individual patients' personalized playlists were created by a certified music therapist (A.B.) through the music assessment questionnaire and we asked the patients to listen to the suggested music every day on their own time. A weekly telephonic follow-up was conducted with each of the participants/care-givers to monitor the progress and document the program's feasibility and efficacy. At the end of the 3 months, CSDD and GDS were performed through telephonic interviews.

Results:
So far we have completed 3 months follow-up with 7 patients (May-August 2023). Based on the weekly follow-ups with the caregivers, we report here that:

- There was a significant difference in pre and post depression scores after the intervention. CSDD, P=0.010 and GDS, P=0.047
- The patients spend a good part of their leisure time listening to the suggested playlists.
- Most of the patients showed a reduction in agitation and restlessness while listening to the music.
- In addition they self-report that they feel less sad or bored.
- One (out of 7) reported that they felt simply more relaxed during listening times.

The present study is on-going and we are recruiting more patients for further data collection and statistical analysis.

Discussion:
In the present study, the Music & Memory Program has been demonstrated here to induce a positive impact on the life and well-being of Indian patient's suffering from dementia as well as the caregiver's. As the patients started spending their leisure time listening to their personalized playlist, their agitation and restlessness was reduced. There is a significant decline in depression level after personalized music intervention. These findings curtail those of the previous work on Music and Memory at the USA in patients with dementia (Music and Memory Report, 2018; Schroeder et al., 2018, Thomas et al., 2017; Vinoo et al., 2017) and support a cross-cultural and cross-lingual validity of the method. The personalized playlists contain songs from the patients' childhood, school and college time and this has helped the caregivers' initiating conversation about old memories with the patients. Again, this is in line with the existing US-based reports on dementia patients (Bakerjian et al., 2020; Music and Memory Report, 2018; Schroeder et al., 2018, Thomas et al., 2017; Vinoo et al., 2017). The study so far has not involved any control data and we intend to involve the controls to compare the effect in near future. In sum, the present work suggests that the use of the individualized music program is feasible and useful in Indian populations with dementia. Their overall quality of life, as assessed by symptoms of depression-related dementia, measures of stress, distressed behaviour, and happiness was shown to have significantly improved after the individualized music program intervention so far and further continuation is in the making.

## One-minute cognitive physiology signals predict treatment outcome in depression as early as two weeks

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INTRODUCTION

Globally, 970 million people live with a mental disorder. Nearly 280 million people worldwide suffer from depression. Suicide is the 4th leading cause of death in people of age group 15-29 years and over 7,00,000 people die due to suicide annually (1). Medication is the first step of treatment against depression. However, 50% are non-responders to the SSRI strategy and treatment requires switching or augmentation with other medications (2). In a study conducted in the US, the remission rate to antidepressants among adults was just 43% and 28% of the non-remitted participants required augmentation with other interventions (3). Other advanced interventions include Behavioral activation, cognitive behavioral therapy, interpersonal psychotherapy and problem-solving therapy. The therapies demand constant and close monitoring of the patient even while the course of therapy (off-sessions) to reliably predict the treatment outcome. However, due to increasing patient to clinician ratio and subjective evaluation, it is hard to successfully predict the efficacy of the treatment plan.

EEG is a cost-efficient and reliable tool to characterize neurodynamics and has been used to extract biomarkers for depression to classify responders versus non-responders for interventions (4). On top of demographics and self-reported measures such as PHQ9, GAD7 and MMSE, we extract biomarkers from EEG data of participants performing various simple cognitive tasks that can efficiently predict the positive change in mental health as early as 7-10 days. Interoception dysfunction is observed in participants with Major Depressive Disorder post presenting a negative emotion stimulus (5). Steady state visual evoked potential (SSVEP) due to flickering stimulus can distinguish mind-wandering, less sticky thoughts and more sticky thoughts (6). Based on the previous literature, we used simple cognitive tasks such as resting state eyes open and eyes closed task, breathing task and varying frequency photic administration task that may trigger interoception and mind-wandering as they are dysfunctional in participants with MDD.

METHODOLOGY

Data collection

EEG data were collected of the participants while performing resting state eyes open task, resting state eyes closed task, breathing task, mini mental state examination and varying frequency photic task. EEG data were collected during baseline visit (0th day), visit 2 (7th-10th day) and visit 3 (30th-40th day). PHQ9 scores were collected during the baseline visit and visit 3.

Data processing

Cleaning of EEG data includes bandpass filtering (0.5-35Hz), bad channels labeling (7), Independent Component Analysis and removal of non-brain components using ICLabel, reconstruction of electrode signals using selected components, interpolation of bad channels and average re-referencing. EGG data was bandpass filtered between 0.03 and 0.07Hz (8).

Feature Extraction

- Fitting oscillations one over frequency method (9) was adopted to separate the periodic and aperiodic component in the EEG signals. Theta (5-8 Hz), alpha (9-12 Hz) and beta (13-30 Hz) band powers were computed using the periodic component.
- Functional connectivity between the signals of two EEG electrodes was computed using magnitude squared coherence. The functional connectivity was estimated for theta, alpha and beta bands.

The extracted features were averaged based on electrode positions: Frontal left (Fp1, F3), Frontal right (Fp2, F4), Central left (C3, T3), Central right (C4, T4), Occipital left (P3, O1) and Occipital right (P4, O2).

Feature selection based on criteria

1. Rank-based correlation was performed between the PHQ9 scores of the baseline visit and the feature values of the baseline visit. This is to scrutinize the features that capture the mental state of the participant defined using PHQ9 scores.
2. Rank-based correlation was performed between the difference of PHQ9 scores of baseline visit and visit 3 and the difference in feature value of baseline visit and visit 2. This is to scrutinize the features that show differences with respect to change in mental state defined using PHQ9 scores.
3. Rank-based correlation was performed between the difference of PHQ9 scores of baseline visit and visit 3 and the difference in feature value of baseline visit and visit 3. This is to scrutinize the features that show consistent differences with respect to change in mental state defined using PHQ9 scores.

Features that show correlation value greater than 0.25 in all 3 criteria are scrutinized for predictive model development.

Predictive model development

Scrutinized feature values of 48 subjects (19 positive change, 29 no change) across all the tasks and visits were extracted

using 1min fragments of EEG signals and were used for model development. Collinear features were removed and mean imputation was used to impute missing data of fragments of various tasks that are shorter than the other. A binary classifier (logistic regression) is used to predict positive change (PHQ9baseline - visit3 >1) in mental health or no change (PHQ9baseline - visit3 <=1) in mental health of the participant. Due to less number of subjects, instead of holdout validation, stratified k-fold (k=5) cross validation was used to assess the performance of the model and choose the best combination of minimal number of scrutinized features using Sequential Feature Addition. Random oversampling of minority class was performed for training data to address class imbalance.

RESULTS

Feature Selection

54 scrutinized EEG features across all the tasks, along with demographics such as age, gender, handedness and presence of history of trauma, and question-wise answers to questionnaires such as PHQ9, GAD7 and MMSE were sequentially selected using Sequential Feature Addition method and were used to develop the Logistic Regression model.

Model performance

The accuracy of the model was 94.7% (~46/48) with 88.2% (~17/19) sensitivity and 99% (~28/29) specificity in predicting the treatment outcome related to change in mental health as measured by PHQ9 scores.

Medication outcome prediction

Out of 48 participants, 17 participants had baseline PHQ9 greater than 5 and were prescribed antidepressants. The model predicted change in mental health correctly for 16 out of 17 participants.

DISCUSSION

In this study, we observed that EEG features mainly acquired from varying frequency photic administration and other cognitive tasks, along with self-reported questionnaires from visit 1 score, are able to efficiently classify participants with positive change or no change in mental health. We also observe that the model is sensitive to >90% for participants with mild (PHQ9: 5 - 9) and moderate depression (PHQ9: 10 - 14) who are showing no changes in mental health. Interestingly, Magnitude squared coherence is a non-directed measure of synchronicity between two signals. Changes in coherence values between EEG recorded from frontal to central brain regions during varying frequency photic task and between central right and occipital right regions during breathing task were key predictors of change in mental health.

This highlights the potential of the model to predict non-response to current medication treatment (serotonin and norepinephrine based) for depression using objective EEG measures and thereby aiding the clinicians to optimize the intervention as early as 7-10 days time.

In future, we aim to use this model for predicting whether the treatment leads to response (at least 50% reduction in initial PHQ9) and also remission (PHQ9 < 5). Further, we will aim to cross validate this model with more participants data and perform clinical trial validation.

**Does the strength of the electric field induced by HD-tDCS influence clinical outcomes in patients with auditory hallucinations in schizophrenia?**

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Introduction

Electro-cortical effects of non-invasive neuromodulation are imperative to understand the optimization of targeted treatment doses. Simulation experiments studying transcranial direct current stimulation (tDCS) have explored an association between the estimated magnitude of electric field (EF) at the region of interest and the clinical improvement in targeted symptoms (Caulfield et al., 2022). However, there is no evidence exploring the therapeutic implications of these parameters secondary to high-definition tDCS (HD-tDCS) which is more focal (Alam et al., 2016). This study examines the strength of EF induced by HD-tDCS at the left temporo-parietal junction (l-TPJ) given for alleviation of persistent auditory hallucinations (AH) in patients with schizophrenia.

Aim: To simulate and examine the electric field induced by HD-tDCS at the l-TPJ given in patients with schizophrenia in a double-blinded, sham-controlled study with concurrent structural MRI (sMRI) data. To study the association between percentage change in symptom score with the estimated local EF.

Methods

Twenty-seven patients (Age 30.9±7.99 years, 13-females) with persistent AH were randomized into a TRUE or SHAM arm for five days of the RCT phase (with concurrent sMRI data at baseline), followed by an open-label extension phase of 5 days of TRUE HD-tDCS. This was to ensure that all patients (irrespective of the arm they belonged to) received a minimum 5 days of TRUE HD-tDCS. The target site for the central electrode at l-TPJ was administered at the CP5 EEG talairach co-ordinate (-61.8, -46.2, 22.5) (Koessler et al., 2009) based on previous literature by using subject-specific MRI-based neuronavigation. Patients received -2mA of cathodal current in the TRUE arm and feeble current mimicking sensory effects (+0.02mA) in the SHAM arm using the 4 X 1 montage at the l-TPJ. Two sessions of 20 minutes duration each, separated by an intersession interval of 3 hours, were given for 5 days (total of 10 sessions). For both TRUE and SHAM arms, AH severity was assessed using the PSYRATS Auditory Hallucination Rating Scale (AHS) (Haddock et al., 1999) at baseline, post 5 days of RCT and post open label extension. Particularly for understanding the electric field correlation with clinical improvement using -2mA cathodal HD-tDCS at the l-TPJ in these patients, AHS values were considered at baseline, after 5 days of TRUE arm in RCT and, after the end of the open-label for SHAM arm (unblinded at the end of the study- as they would have received -2mA of cathodal current in the open label extension phase). Response was defined as >20 % improvement in the AH-PSYRATS score from baseline (Leucht et al., 2006). The region of interest (ROI) TPJ was identified between the four return electrodes i.e. FC3, FT7, P1 and P7 as the electric field is distributed within this circumference based on the 4x1 HD tDCS montage. Individualized EF was estimated at region of interest (ROI) i.e. at l-TPJ in all subjects retrospectively using a simulation technique using SimNibs software.

Results

After quality check, data for 3 subjects was discarded. In the simulation analysis (n=24), percentage change in AH-PSYRATS score negatively correlated with the local electric field magnitude ($r = -0.448$; $p = 0.028$, linear $r2 = 0.149$) at the l-TPJ. Scatter plot showed maximum responders (6 out of 10) and only 1 out of 14 non-responders (Leucht et al., 2006) having mean local EF between 0.14 V/m to 0.18 V/m. The receiver operating characteristic curve (ROC) was evaluated, and specificity, sensitivity, and Youden's indices in differentiating responders from non-responders were derived. The EF magnitude of 0.182 V/m had the highest Youden's index, with 80% non-responders and 60% responders being classified correctly.

Conclusions

The lesser magnitude of an electric field at the left TPJ was weakly associated with greater reduction in the AH. However, on further examination, it was seen that responders (6/10) had mean local EF in the ROI within the range of 0.14 V/m to 0.18 V/m while non-responders (12/14) had >0.20 V/m EF. Empirical evidence in EF studies with tDCS has found mean local EF in range of 0.15 to 0.20 V/m in the ROI to be associated with clinical improvement (Suen et al., 2021). Perhaps, electric field created secondary to HD-tDCS is greater and is not comparable with that of conventional tDCS with the same targeted current intensity. This study suggests the possibility of a specific window of EF strength within which neuromodulation-based effects are most pronounced. It also encourages the use of subject-specific optimization of neuromodulation parameters to achieve maximum intended effects at the target ROI. However, given the limited sample size, the classification accuracy between responders and non-responders is warrants a more strategic data analysis method and systematic exploration.

**Effectiveness of High-Intensity Interval Training (HIIT) for Cognitive Rehabilitation of young adults with Obsessive-Compulsive Disorder**

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1. Introduction

Obsessive-Compulsive Disorder (OCD; ICD F 42.0) is a debilitating condition affecting roughly 2.5% of the population (Kessler et al., 2012). It is characterized by persistent and time-consuming obsessions and/or compulsions that severely disrupt daily life, leading to a decline in quality of life, increased psychosocial difficulties, and higher healthcare utilization among patients (Osland et al., 2018). OCD is associated with cognitive deficits, attentional biases toward threatening stimuli, memory problems, and difficulties in accessing internal states. The disorder is believed to stem from disruptions in the cortico-striato-thalamo-cortical (CSTC) circuitry, particularly the "frontostriatal" concept, where an imbalanced feedback loop results in hyperactivity in the orbitofrontal and subcortical circuits. This hyperactivity leads individuals with OCD to display a preference for and excessive attention to dangerous stimuli, fueling obsessive behaviors. The dominant neurobiological model predicts neuropsychological deficits, primarily in executive function, linked to the frontostriatal system, as observed through functional imaging during neuropsychological tasks (Pauls et al., 2014).

OCD poses a significant public health challenge, with current treatments like medication and psychotherapy often falling short, resulting in symptom relapse. Challenges in tolerating exposures and the presence of coexisting mental health issues can further complicate treatment (Brauer et al., 2011). Therefore, there's a need for more accessible and low-risk alternatives. High-intensity interval training (HIIT), a time-efficient exercise approach, has shown promise in improving mental health in various disorders, including mood and anxiety disorders (Martland et al., 2020). The outcomes from a randomized controlled trial conducted by Abrantes et al. (2019) provide insights into the potential mechanisms through which exercise can impact OCD outcomes. Additionally, these results indicate the possibility of formulating exercise interventions that enable individuals to employ individual episodes of physical activity as an in-the-moment approach to improving mood and reducing anxiety and compulsive behaviors (Abrantes et al., 2019). HIIT involves short bursts of high-intensity exercise followed by recovery periods. This vigorous exercise stimulates the production of growth factors, such as brain-derived neurotrophic factors, which are linked to enhancing brain function (Jiménez-Maldonado et al., 2018). Consequently, consistent HIIT might lead to more significant improvements in higher-order cognitive abilities compared to less intense training. Exploring HIIT as an OCD treatment is a promising avenue to address the limitations of current therapeutic approaches.

The study's objectives include assessing the effects of HIIT on response inhibition, planning abilities, set-shifting, verbal fluency, and visuospatial working memory (VSWM) in young adults with OCD. The literature review emphasizes the role of executive functions in OCD and the potential benefits of HIIT, backed by its positive effects on physical and mental health in various populations. Overall, the study aims to provide valuable insights into the potential of HIIT as an effective and accessible treatment option for OCD, targeting cognitive functions crucial for individuals' overall mental health and well-being.

Methods

The study design is a matched-group, pre-post, single-blinded, prospective, experimental study. It involved 68 young individuals [HIIT group: n=32 (Mean age= 25.75 years, SD= 2.71); control group: n=36 (Mean age= 26.67 years, SD= 3.48)] diagnosed with OCD recruited from government hospitals in Kolkata, West Bengal. To participate, individuals had to meet the ICD-11 criteria for OCD, be familiar with using personal computers, engage in minimal physical activity, and understand instructions in English, Bengali, or Hindi. Exclusion criteria included various medical conditions, recent surgery, high resting heart rate or blood pressure, orthopedic issues, cognitive impairment, depression, other mental health disorders, or the use of certain drugs. The severity of OCD in patients was not taken into consideration for this study.

Sociodemographic Data Form was used to gather participant sociodemographic and clinical information. Beck's Depression Inventory (BDI) and Mini-Mental State Examination (MMSE) behaved as screening tools. Psychology Experiment Building Language (PEBL) version 2.1 (open-source software package) was for assessing executive cognitive functions through specific tasks: Go/No-go Task (GNG) to evaluate reaction inhibition, Tower of London (ToL) to assess planning abilities, Berg Card Sorting Test (BCST), for set-shifting and frontal lobe function assessment, and Corsi Block Task (CBT) to evaluate visuospatial working memory. Phonemic Verbal Fluency Test (PVF) F-A-S, was used to assess fluency by having participants generate words starting with specific letters. The selection of these specific tasks was driven by an extensive examination of the neuropsychological literature concerning Obsessive-Compulsive Disorder (OCD) as conducted by Abramovitch and Cooperman (2015), in which they conducted a critical assessment of performance on neuropsychological tests categorized by domains, investigated potential factors influencing neuropsychological functions, explored proposed endophenotypes, and examined neuropsychological indicators for treatment response (Abramovitch & Cooperman, 2015).

Procedure

Before the trial commenced, participants referred underwent a thorough eligibility evaluation and obtained written medical clearance from their attending physician. All participants provided informed written consent to participate in the study. Participants' diet, medications, and psychotherapy were unchanged during the study. Participants were randomly assigned to either the experimental (HIIT) group or the control group. To ensure both groups were balanced in terms of gender, a stratified randomization approach was used.

The study spanned six weeks and took place at hospital campuses. Participants underwent assessments both before and after the intervention. From the second week onwards, the experimental group engaged in fitness training, while the control group spent equivalent time reading periodicals and books. All assessments were conducted in a controlled laboratory environment to ensure consistency.

Exercise intervention. Over the duration of a 12-minute circuit training session, participants completed four full-body exercises: jumping jacks, modified burpees, side jumps, and high knees. The workout was performed three times, with each repeat involving 30 seconds of effort and 30 seconds of rest, thrice a week. The modification of this circuit was made in response to the Ludyga et al. (2019) study. The exercise's time has been trimmed to 12 minutes to enable the study's sample of patients to complete it. The participant's heart rate (HR) was monitored using a Polar Heart Rate Monitor. The heart rate of participants will be encouraged to remain at or above 80% of their expected maximum heart rate.

Statistical Analysis

The data were analyzed using IBM SPSS Statistics for Windows, Version 25.0 software. A chi-squared test was used for the categorical variable of gender. The non-normally distributed data were analyzed using the Mann-Whitney U test and Wilcoxon Signed-Rank test. $P<0.05$ was considered statistically significant in all of the analyses.

Results

There was no statistically significant difference between the control and experimental (HIIT) groups in terms of the socio-demographic variables (age and gender) and screening variables of Beck's Depression Inventory (BDI-II) and Mini-Mental Status Examination (MMSE).

It was revealed that in the post-test, the reaction time of the No-Go condition of the GNG task ($U=71.32$, $p<0.05$) and the number of perseverative errors in BCST ($U=212$, $p<0.05$) in the HIIT group were significantly lower. In contrast, the mean accuracy of the GNG task ($U=399$, $p<0.05$), memory span ($U=347$, $p<0.05$) and total number of correct responses ($U=411$, $p<0.05$) in CBT were significantly higher than controls.

In the case of HIIT experimental group, the reaction time in the No-Go condition of the GNG task ($W=390.0$, $p<0.05$), total number of extra moves in ToL task, number of perseverative responses ($W=429$, $p<0.05$) and perseverative errors ($W=363.5$, $p<0.05$) in BCST were significantly lower in the post-test whereas, the mean accuracy of the GNG task ($W=136.5$, $p<0.05$) and the memory span in CBT ($W=84$, $p<0.05$) were significantly higher in the post-test.

Discussion

The results suggest that HIIT may have a positive impact on cognitive functions related to response inhibition, planning abilities, set-shifting, verbal fluency, and visuospatial working memory in individuals with OCD. These cognitive functions are crucial for daily life and overall mental well-being for working young adults. The study provides valuable insights into the potential benefits of HIIT as an adjunct therapy for individuals with OCD, addressing cognitive deficits commonly associated with the disorder. The findings contribute to the growing body of research on exercise interventions for mental health conditions, offering a potentially accessible and low-risk alternative to traditional treatments. Further research and larger-scale studies are warranted to confirm these promising results and explore the long-term effects of HIIT on cognitive functioning in individuals with OCD.

## Does pupil dilation reveal an anxious forager?

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Animals, including humans, are optimal foragers in that they follow the normative model called the Marginal Value Theorem to optimize the gains in a patchy environment (Charnov 1974). However, previous studies have revealed individual differences in foraging and attributed this partially to stress and anxiety ((Yonce et al.2021, Lenow et al., 2017). However the underlying mechanism relating stress and anxiety to suboptimal foraging has yet to be revealed. We hypothesize that trait anxiety may impact stress neuromodulators like cortisol and norepinephrine and those in turn may affect foraging.

Studies in trait anxious individuals have reported higher baseline levels of cortisol (Schlotz et al., 2006) and lower levels of central norepinephrine (Zalachoras et al., 2022). Further, research by Aston-Jones's group (Aston-Jones & Cohen, 2005) has shown locus coerulus-driven norepinephrine system(LC-NE) drives explore-exploit decision-making and that pupil size is a readout of NE signaling and decision making. But how cortisol and NE based mechanisms affect patch foraging in trait anxious individuals has yet to be examined. First, we examine the impact of patch foraging on pupil size that we consider a readout of the underlying mechanisms (Aim 1), before investigating the impact of trait anxiety and cortisol on pupil size (Aim 2).

Although previous studies have not examined pupil size during foraging, there are some clues available from other such explore-exploit tasks. For example, Aston-Jones & Cohen (2005) and later (Jepma & Nieuwenhuis, 2011) showed that tonic LC firing was related to tonic pupil dilation which increased to a maximum when the subject wanted to disengage or explore. Based on this result, we expect tonic pupil size to increase to a maximum before the patch leave trial. However, studies examining conflict have also observed pupil dilation.(Shenhav et al., 2014) According to this literature, as the reward value of the patch goes down, the conflict increases to a maximum – when the stay and leave decisions have equal value. Pupil dilation reflective of conflict should peak at this time. Followed by a decrease in dilation until the leave trial – resulting in an inverted-U pattern (van der Wel & van Steenbergen, 2018)(Kurniawan et al., 2021). We examine these hypotheses in Aim 2.

Further, we know from earlier work that reward availability affects pupil dilation with higher rewards eliciting higher pupil dilation (Van Slooten et al., 2018). Here in the task, travel time between patches modulates global reward availability – higher the travel time between patches, lower the reward availability. So we expected the high travel time condition to show lower tonic pupil dilation if pupil dilation is a reliable indicator of reward availability – which was again tested as part of Aim 2.

Lastly, we investigated if baseline cortisol level modulated pupil size. We hypothesized that high cortisol would lead to low reward sensitivity, which would lead to lower pupil dilation (Kinner et al., 2016)(Van Slooten et al., 2018). This was tested in Aim 3. Note: NE-based mechanisms will be examined later on.

Methods:

For the patch foraging game, we adopted the one developed by Yonce et al (2021). In this game, the participant can harvest fruits at every patch. Every patch carried reward. However, the amount of fruits collected (or the reward) decreased with every harvest and the amount of harvested number of fruit was shown immediately after a trial (feedback). In leave trial no reward was obtained. At any given point, they can decide to move to the next patch which will provide a high reward. But of course they will lose some time traveling to this patch. So, at any point in time, whether to stay at the current patch or leave to the next one is the crucial decision that they have to make, in order to collect as much reward in the finite amount of time available.

A total of 55 participants took part in the study. Once before and once after the game, they self-reported state and trait anxiety levels based on the STAI scale. We also collected saliva samples in these epochs for cortisol assessments. The game lasted 12 mins and consisted of a 2-min training block. A 5-min short travel time block - travel time between patches is 3 seconds, and a 5-min long travel time block - travel time between patches is 10 seconds - followed the training block. We collected EEG data, eye movements and pupil size measures during gameplay.

Result :

1. Does trait anxiety affect patch foraging?

First, to understand the optimality of foraging decisions, an optimal agent was simulated based on the Marginal Value Theorem for each participant using their average response time (or harvest time). Next, the deviation from the optimal stay duration per patch was calculated by finding the difference between the simulated optimal and the observed stay duration. The above histogram shows the deviation from optimal stay duration for all participants in short and long travel time

environments (Fig 3: short - pink, long - Cyan). While the histogram is centered around zero, and the deviation from the optimal was limited to 5 secs, participants tended to either overharvest or underharvest. To investigate whether under-harvesting is related to trait anxiety as observed in a previously unpublished dataset (Ramakrishnan et al), we developed a mixed regression model with patchwise stay duration as the dependent variable and travel time between two patches, harvest time, and trait anxiety score as fixed effects. As expected, when the travel time between patches increased, participants' stay duration in a patch increased (LMM: 2.85e-01 +- 1.89e-02; p= <2e-16; 1000 Bootstrap: l: 0.194 h:0.383). Finally, with increase in trait anxiety, stay duration decreased (LMM: -1.89e-01+/-1.06e-01,P<=0.08,1000 Bootstrap, l:-0.345 h:-0.040). Note that this regression model was better than the model without trait anxiety (ANOVA: p = 0.07869).

2. Aim 1: Does foraging impact pupil size?

As mentioned in the Introduction, according to Aston-Jones & Cohen (2005) and later (Jepma & Nieuwenhuis, 2011) we expected tonic pupil size to increase to a maximum before the patch leave trial. However, as per conflict resolution hypothesis, pupil dilation reflective of conflict should peak in the middle, followed by a decrease in dilation until the leave trial – resulting in an inverted U pattern (van der Wel & van Steenbergen, 2018)(Kurniawan et al., 2021).

When we plotted the tonic pupil size (average of 1 sec of data during a stable pre-decision epoch), we observed an inverted U shape for pupil dilation in the foraging task (Figure 4). These results are more aligned with the conflict hypothesis although more rigorous analysis is still underway.

Left align - trials are aligned to the first stay trial (x=1) ; Right align - trials are aligned to the leave trial (x=15; x=14 would be the last stay trial and so on).

Further, we know from earlier work that reward availability affects pupil dilation with higher rewards eliciting higher pupil dilation (Van Slooten et al., 2018). So we expected the high travel time condition, synonymous with reduced global reward, to show lower tonic pupil dilation. When we plotted the pupil size for the short and the long travel time environments (Figure 5), we observed exactly that: pupil dilation was reduced in the longer travel time environments. The results from the linear mixed model (pupil ~ reward + travel time + harvest time) also revealed strong travel time effects on pupil size(LMM:-2.917e-02 +/- 9.826e-03,P<=0.003,1000 Bootstrap, l-0.038165813 h:-0.0035)

3. Aim 2: Does trait anxiety impact pupil size during foraging?

To test this we grouped participants according to their trait anxiety score. We expected high trait anxiety participants who are known to be less sensitive to reward (Van Slooten et al., 2018) to exhibit lesser pupil dilation. In fact, the high trait anxious individuals showed lesser pupil dilation while foraging (Figure 6).

Further, a mixed regression model taking pupil dilation as a dependent variable could show that it depended on the interaction of trait anxiety and total reward gain in a patch (LMM: -2.268e-02 +/- 1.062e-02, P=< 0.0032,1000 bootstrapped, l: .03146, h: 0.0668) clearly demonstrating that pupil diameter is influenced by trait anxiety.

4. Aim 3: Does baseline cortisol level affect pupil dilation during foraging?

Lastly, we investigated if baseline cortisol level modulated pupil size. We hypothesized that high cortisol would lead to low reward sensitivity, which would lead to lower pupil dilation (Kinner et al., 2016)(Van Slooten et al., 2018). To test this we developed a mixed regression model. As expected, baseline salivary cortisol level (sample collected before the participant played the foraging game) negatively affected pupil size (LMM: -3.173e-02 +/- 1.271e-02 ; p= <0.00141;1000 Bootstrap: l: -0.0554869530 h:-0.006292282) and the stay duration(LMM: -7.234e-02 +/- 8.640e-03; p= <2e-16; 1000 Bootstrap: l: 0.194 h:0.383). These results demonstrate that both trait anxiety and baseline cortisol reduced patch stay duration and pupil dilation in the foraging game.

Interestingly, though both trait anxiety and baseline cortisol acted as a significant affector on pupil dilation, or in other words pupil acted as a readout for both, no significant relation was found between baseline cortisol level in individual and their trait anxiety level. To investigate the following I have run a linear model taking cortisol level as the dependent variable and the trait anxiety level as the affector, but the result suggest there is no significant relation between them. (LMM: -0.065334 +/- 0.139180 ; p= <0.641)

Discussion:

The objectives of the studies will help us understand the vulnerability of trait-anxious individuals towards developing clinical anxiety later in life. It also gives us the insight on how chronic and acute daily life stress can affect this relationship between trait anxiety and anxiety disorders. To understand the neuronal system level mechanism of the aforementioned causal relationship we investigate the relation between pupil dilation and trait anxiety, and pupil dilation and patch foraging – where pupil dilation acts as a putative marker of neural system LC-NE, which engages in both explore-exploit decision making process and NE driven changes under stress and anxiety. This whole relationship between neuromodulators(cortisol and norepinephrine), decision-making ability, and pupil dilation as a read out of neuronal circuitry driving decision and stress related response can give us better understanding in diagnosis of individual suffering with clinical anxiety. It will also help us to better understand the neuronal mechanism involved in developing such disorders.

Through our study, we show that trait anxiety and cortisol increase exploratory tendencies in foraging and this can be evidenced through pupil dilation. Currently, we have not yet looked at norepinephrine-based mechanisms or the EEG data to further support the claims.

# Does Local Processing enhance Inhibitory Control?

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Introduction

How and what we attend to is very fundamental to what we see and perceive. Thus any change in attentional processing orienting (Lupyan, 2017), and resizing (Goodhew, Shen, & Edwards, 2016) affects visual processing. The spatial scope of attention has been shown to affect different aspects of visual perception e.g. visual awareness (Baijal & Srinivasan, 2010; Srinivasan & Singh, 2017). A more narrow scope of attention leads to faster and more accurate performance in visual discrimination (Lawrence et al., 2020), and better spatial resolution in visual processing (Carrasco et al., 2000).

Attentional processing is also linked to inhibitory control (Meyer et al., 2020). These two functions are closely intertwined, as effective attentional allocation is essential for successful inhibitory control (Draheim, C., Pak, R., Draheim, A.A. et al., 2022). When individuals allocate their attention selectively, they enhance their ability to identify relevant cues and adjust their responses accordingly (Stevens & Bavelier, 2012). A go/no-go task is a commonly used paradigm to study inhibitory control (Monterosso et al., 2005; Reynolds et al., 2007; Menella et al., 2017; Gao et al., 2019). This task requires participants to respond quickly and accurately to a frequent "go" stimulus while refraining from responding when an infrequent "no-go" stimulus is presented. Successful performance on the go/no-go task relies on the individual's ability to inhibit a prepotent response tendency in the presence of the no-go stimulus. Inhibitory control involves the capacity to suppress automatic or dominant responses in order to facilitate more appropriate and goal-directed behaviors. The dynamic interplay between attention and inhibitory control underscores their shared role in shaping adaptive behaviors and cognitive flexibility. In the present study, we aim to investigate the link between the spatial scope of attention and inhibitory control using Navon Letters in a Go/No-Go paradigm. Here we want to investigate the effect of change in spatial resolution as a function of spatial scope of attention on the inhibitory control. We expect that, since the spatial scope of attention leads to changes in spatial resolution, the inhibitory control will be better with the local stimulus (narrow spatial scope of attention and better spatial resolution) compared to the global stimulus (broad spatial scope, poor spatial resolution). We expect faster RTs and high accuracy for inhibition when processing local stimuli as compared to global stimuli.

Method

Participants

A total of 35 participants (mean age = 22.5) with normal or corrected to normal vision voluntarily participated in the study. The number of participants (34) was calculated using the software G*POWER 3.1 according to the experimental design, and by using the following parameters: Power = 0.9 and effect size = 0.5. Participants for this study were undergraduate and postgraduate students of the University of Allahabad with working knowledge of English.

Stimuli

The experiment uses Global and Local stimuli, i.e., Navon Letters. Local stimuli refer to many small stimuli arranged together to form a global shape, while Global stimuli refer to stimuli that are composed of many local elements (Baijal & Srinivasan, 2009).

Procedure

The experiment had 2 blocks - “Global Go” and “Local Go " Blocks. The participants performed a go/no-go task in each block. Each block consisted of a total of 175 trials with 130 go-trials and 45 no-go trials. In each block, each trial started with presenting a black fixation cross in the middle of the screen for 500 ms followed by the presentation of the stimulus S or H, at a global level and the local level for 300 ms. After the stimulus disappeared from the screen, a response window appeared with a red fixation cross on the screen for 1500 ms where the participants had to make a response. The red fixation cross disappears as soon as the participants make a response. It was followed by a blank screen for 280 ms acting as an ITI. The participants were asked to press “a” for global “S” in global go block (go trials) and inhibit response for any other stimulus (no-go trials). The participants were not made aware of the duration of the response window and were told to respond as soon as possible.

Similarly, in local go blocks, they had to press “l” for local “S” and inhibit response for all other stimulus types. After finishing the first block (175 trials), there was a compulsory break of 2 minutes. The order of presentation of blocks was counterbalanced among participants to avoid any order and practice effects.

Results and Discussion

Reaction Time. Data was filtered for incorrect trials i.e. no-go trials in which participants responded and go trials where they did not make any response; it was also filtered for the trials which has a reaction time of less than 120 ms. A paired sample t-test was conducted for the reaction time data, where Local Go RT (M=345.62, SD=112.99) > Global Go RT (M=313.98, SD=81.44), $t(25) = 1.869$, $p = 0.035$ Results suggest that assessing global stimuli requires less time as compared to assessing local stimuli suggesting a Global Precedence Effect.

Accuracy. Data was filtered and subjects with an accuracy of less than 80% in either of the two blocks were removed from

the accuracy analysis. We were left with 26 subjects' data for the accuracy analysis of no-go trials. A one-tailed, paired sample t-test was conducted which suggests that the accuracy for the local no-go (M=94.1, SD=0.047) was higher than the global no-go (M=92.8, SD=0.046), t(25) = 1.412, p = 0.085. The results possibly indicate that the better spatial resolution associated with the local processing may result in higher inhibitory control, as suggested by a close to significant effect. The criteria for accuracy has been kept such as to exclude any responses that might be guess responses and hence kept the responses only where the reaction time was more than 120 ms. A study on human perception suggests that it requires at least 50 ms to allocate attention to a visual stimulus (Duncan, Ward & Shapiro, 1994); other more recent studies suggest that it requires at least 150 ms to shift attention from one object to another in the visual space (Jenkins, Grubert, & Eimer, 2018). Thus we decided on keeping a 120ms filter for the correct responses recorded.

Overall the results are suggestive that the spatial scope of attention is linked to inhibitory control and the enhanced spatial resolution linked with local processing possibly results in increased inhibitory control. Losing 8 participants from the no-go accuracy analysis is a possible reason for not getting a significant effect (p = 0.085). We are collecting more data to make the sample size 34 which was our estimated sample size.

Keywords: scope of attention, inhibitory control, global processing, local processing

## Drug-reinforcement impairs cognitive flexibility by inhibiting striatal cholinergic neurons

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Introduction

Addictive drugs cause cognitive inflexibility, however, the underlying neural mechanism is unclear. It is known that striatal cholinergic interneurons (CINs) regulate flexibility, therefore, we investigated whether CIN activity, or their inputs, are altered by drug exposure. Next, we found that CINs receive majority inhibitory inputs from striatal dopamine D1R-expressing medium spiny neurons (D1R-MSNs). Since D1R-MSNs mediate rewarding behaviors, we hypothesized that the inhibitory D1R-MSN CIN transmission is upregulated after drug exposure, causing reduced CIN activity, downregulating cognitive flexibility. Our studies suggest that the D1R-MSN CIN transmission mediates the drug-induced concurrent reduction in cognitive flexibility.

Methods

Slice Electrophysiology: Coronal sections of the dorsomedial striatum (250 µm) were cut and stored in artificial cerebrospinal fluid. Measurements: Inhibitory post-synaptic currents (IPSCs), excitatory PSCs (EPSCs), paired-pulse ratio (PPR), AMPAR/NMDAR ratio, AMPA-induced currents. Stimulation methods: optogenetic, electrical and pharmacological.
Behavior: Cocaine-induced hyperlocomotion, cocaine intravenous self-administration, intracranial optogenetic self-stimulation of D1R-MSNs, sucrose self-administration two-action (A)-outcome (O) reversal learning task, extinction learning intermittent-access to alcohol procedure.
Animals: Experiments were conducted in 4-7 month-old male and female mice/rats. Transgenic mice: ChAT-eGFP, ChAT-Cre;D1tdT, D1-Cre;ChAT-eGFP, D1-Cre;Ai32;ChAT-eGFP, D1-Cre;ChAT-eGFP, D1-Cre;Ai167;ChAT-eGFP. Transgenic rats: wild-type, D1-Cre, ChAT-Cre;tdT. Sample sizes were estimated using SigmaPlot using expected difference in means, standard deviation and desired alpha. All animal care and experimental procedures were approved by the Texas A&M University Institutional Animal Care and Use Committee.
Data analysis: Statistical analyses were performed using SigmaPlot. Normal distribution was tested and unpaired t test, paired t test or two-way RM ANOVA followed by post-hoc Tukey test were used to determine statistical significance as appropriate, with an alpha value of 0.05. Mixed model ANOVA followed by simple effects test was conducted for Figure.1 and Figure.5 in SPSS. All statistical tests conducted in this study were two-sided.

Results

Cocaine exposure impairs cognitive flexibility

Wild-type mice received intraperitoneal injections of cocaine or saline and underwent training on a reversal learning task (Fig. 1a). After initial training, devaluation test confirmed learned associations (Fig. 1b). However, post-reversal training, only saline group displayed devaluation sensitivity (Fig. 1c).

Cocaine enhances CIN inhibition

DMS CINs were recorded from mice trained to self-administer cocaine (Fig. 2a). Cocaine-induced reduction in CIN firing was observed (Fig. 2b), with potentiation in GABAergic inputs, as indicated by increased sIPSC frequency, eIPSCs and decreased eIPSC PPRs (Fig. 2c-g).

CINs receive striatal inputs primarily from D1R-MSNs

Anatomically, more inputs to CINs from D1R-MSNs than D2R-MSNs were observed (Fig. 3a-b). D1R-MSN stimulation generated more robust inhibitory responses in CINs. Additionally, lever-pressing, associated with D1R-MSN activity reduced acetylcholine levels, suggesting CIN inhibition in-vivo.

Drug reinforcement potentiates inhibitory D1R-MSN→CIN transmission

Cocaine increased AMPAR/NMDAR ratios and AMPA-induced currents in D1R-MSNs, causing enhanced downstream D1R-MSN→CIN transmission. Cocaine and not sucrose induced D1R-MSN-mediated suppression of CINs persisted after prolonged withdrawal (Fig. 4a-c). Similarly, chronic alcohol consumption and D1R-MSN self-stimulation also potentiated D1R-MSN→CIN transmission.

CIN inhibition impairs cognitive flexibility

During initial training, eNpHR rats and controls showed comparable performance (Fig. 5a,b). During reversal training, light (590 nm) inhibited CIN activity in eNpHR rats. Unlike controls, eNpHR rats were insensitive to outcome devaluation post-reversal training (Fig. 5d). DMS CIN inhibition also impaired extinction learning.

Discussion

To conclude, here, the D1R-MSN CIN circuit was linked to drug-induced flexibility deficits, highlighting its role in reinforcing behaviors' impact on decision-making and flexibility. This insight has clinical implications, suggesting the potential use of cholinergic drugs to alleviate cognitive side-effects of drug exposure and addressing compulsive behaviors in individuals with substance use disorders. Future directions include: 1) Rescuing drug-induced inflexibility, 2) Investigating how reduced CIN activity impact the local striatal circuitry to affect flexible behaviors.

## A novel approach for analyzing the Heider and Simmel Animation

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Introduction:
The Heider and Simmel animation (henceforth referred to as 'H&S animation'), first proposed in 1944 (Heider & Simmel, 1944) is perhaps one of the most influential animations in the history of Cognitive Psychology. The dynamic movement patterns created by the objects (i.e., small triangle, big triangle and circle) and their interaction in the animation determine the observer's anthropomorphic descriptions of the sequence (Berry et al., 1992, Shu et al., 2018). This 90 second animation has been used in thousands of studies to investigate diverse questions, including the perception of animacy (Rutherford & Kuhlmeier, 2013; Parovel, 2023), and the ability to derive rich social narratives (Heberlein, 2008; Huang et al., 2023). In much of the work so far, the content of the H&S animation has been characterized qualitatively, as a high-level linguistic description. While adequate in some settings, this limits our ability to titrate the precise factors in the sequence that may be responsible for shaping observers' interpretations. Previous literature elucidates the significance of temporal correlations obtained from kinematic trajectories leading to animacy judgements and causality attribution (Rime et. al, 1985; Scholl, 2000). However, the extent to which low-level animation factors (simple animation metrics like shapes proximity and movement correlation) may contribute to the observer's interpretation of social meaning needs further exploration. To address this need, we propose a computationally driven characterization of the dynamic trajectories in the H&S sequence, and compare these with a control sequence with random trajectories, thereby allowing us to assess the degree of influence low-level animation factors may potentially have in making high-level interpretations. Besides comparing semantically meaningful and non-meaningful sequences, we also use our computational characterization to formulate a hypothesis regarding why patients from Project Prakash might have been unable to interpret the H&S animation in a manner akin to normally sighted controls. We have undertaken studies to test this hypothesis.

Methods:
We ran a computer vision program using python to perform object detection and tracking of all moving objects in the H&S animation and in another animated sequence that we generated, devoid of high-level semantics. Each of these animations had over 1500 frames. Within each frame, we determined the x and y coordinates of each visible object, and created a log of all of these coordinates across the entire animation. We then separated the 2-Dimensional positions and trajectories into two 1-Dimensional positions and trajectories. These 1D time-series from each object were correlated with the corresponding time-series from the remaining objects. The results were summarized as 3x3 correlation matrices (showing how the 1D trajectory of each object correlated with the 1D trajectory of the other two). In addition to computing the correlation values across the entire temporal extent of the two distinct animations, we also determined short-term correlations within sliding windows of 100 frames each.

Results:
We found that the H&S animation showed higher pair-wise correlation values than the non-semantically meaningful animation. Furthermore, the analysis with sliding windows revealed specific epochs in the H&S animation when the pair wise correlation values were especially high. The non-meaningful sequence showed no such epochs. These results suggest that inter-object temporal correlations potentially play a role in eliciting social attributions.

Discussion:
Our results indicate that a fine-grained analysis of movement trajectories of objects in the H&S animation, and other sequences like it, may be a useful approach for characterizing such stimuli, and specifically for assessing whether they are likely to support social attributions. This hypothesis offers an interesting conjecture regarding why Prakash patients are unable to perceive social narratives in the H&S animation (results presented during last year's conference): They may be compromised in the task of temporal correlation detection. We have tested this conjecture by assessing Prakash patients' correlation detection abilities and have found that while not entirely lacking in this skill, they show some compromise relative to normally sighted controls, and also appear to require longer sequence duration to detect correlations. We shall discuss the possibility of these compromises as a potential account of Prakash patients' performance on the H&S animation.

# Is mine always better? Evidence for ingroup bias moderation through information dynamics in group relations

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Introduction

Social context plays a significant role in much of our daily life cognition, including the choices we make, the attitudes we hold, the political ideologies we ascribe to, and many such others. Social categorization is a phenomenon or, more precisely, a concept where we classify individuals or groups of individuals into various social groups. These social groups can be broadly divided into "ingroups," groups to which an individual belongs, and "outgroups," groups to which the individual does not belong. Social categorization influences how we conceptualize our social group in relation to other social groups, and it is demonstrated in the ways we process information about ingroups and outgroups differently. Prior literature on ingroup bias highlights a consistent preference for ingroup in many decision-making tasks. More recently, research on similar lines has demonstrated that individuals respond faster and more accurately to information associated with the 'self' vs. the 'other,' and also with an ingroup compared to an outgroup. For this study, we use a social associative matching paradigm in a minimal group setup across four experiments to assess how changing narratives about ingroup and outgroup and their relation elicit contrasting perceptual responses. We also calculate group affinity scores in experiments 2b and 2c to investigate asymmetries in associating ourselves with various social groups.

Methods

Our first experiment was a replication of Experiment 1 from Enock et al., 2020, with few changes for our study. Using the minimal group setup, we categorized participants into one of the two groups, GHLEN and PHINS. The group names were English non-words, with no meaning of their own and thus, novel for each participant. Two geometrical shapes, stars and crosses, represented GHLEN and PHINS groups, counterbalanced. Ten different variations of the geometrical shapes, varying in orientation, angle, and skewness, were used instead of one single shape to denote the groups. These variations in shapes represented a community comprising different members but essentially belonging to the same group.

Participants completed the associative matching task adapted from Sui et al., 2012. The task comprised an association block, practice block and the main experimental block, and took approximately 20 minutes to complete. Upon arriving at the experimental session, group allocation was done such that the odd-numbered participants were allocated to GHLEN, and the even-numbered participants were allocated to PHINS. Participants received the corresponding instructions according to their group allocation.

All four experiments were run with a similar setup with different sets of participants (33 in each). The only thing varying in these four experiments was the group relation. In experiment 1, there was no story about group relations, just the existence of two groups in a hypothetical society. This provided us with the baseline condition for establishing ingroup bias. In experiment 2a, the group relation was shown to be positive, with both groups living peacefully in society. In experiments 2b and 2c, the groups' relations were conflicted. In experiment 2b, the outgroup was portrayed as highly discriminative, and problem creator for society, whereas in experiment 2c, the ingroup was the discriminatory and problem creator of the two groups.

Results

Response times higher or lower than 2.5 standard deviations from the mean response time for each participant under each condition were excluded. We carried out paired samples t-tests on the RT, Accuracy, sensitivity score and response criterion for all experiments. All analyses reported are for the matched condition. For experiment 1, we established a baseline ingroup bias in terms of higher RT, $t(32) = -2.865$, $p = 0.007$, higher accuracy, $t(32) = 3.139$, $p = 0.004$, higher sensitivity score, $t(32) = 2.565$, $p = 0.015$, and lower response criterion, $t(32) = 3.107$, $p = 0.004$.

For experiment 2a, upon providing a neutral-to-positive narrative about group relation, the ingroup bias seemed to disappear, with significant differences present only in the sensitivity score. The p values for RT $t(32) = -1.801$, accuracy $t(32) = 1.952$, sensitivity score $t(32) = 2.446$, and response criterion $t(32) = 1.286$, were 0.081, 0.060, 0.020, and 0.208, respectively. In experiment 2b, the ingroup bias appeared again strongly when participants were provided with a conflicted narrative about group relation, the outgroup being the negative of the two groups. The p values for RT $t(32) = -3.841$, accuracy $t(32) = 4.058$, sensitivity score $t(32) = 3.121$, and response criterion $t(32) = 4.185$, were 0.00054, 0.00029, 0.0038, and 0.00020, respectively. For experiment 2c, the relation between the groups was again conflicted and participants associated themselves with the negative group. The ingroup bias again seems to vanish, being significant only for RT. The p values for RT $t(32) = -2.039$, accuracy $t(32) = 1.579$, sensitivity score $t(32) = 1.284$, and response criterion $t(32) = 1.680$, were 0.050, 0.124, 0.208, and 0.103, respectively.

To calculate group affinity scores in experiments 2b and 2c, participants responded to a questionnaire set consisting of 7 questions. We found the scores differed significantly from each other, $t(64) = 5.114$, $p < 0.001$, with participants showing higher group affinity when they associate themselves with the positive group (exp 2b) compared to when they associate

themselves with a negative group (exp 2c).

Discussion

In this study, we show how ingroup biases manifest themselves in lower-level perceptual matching tasks under varying social contexts. The findings have implications for understanding how our belief shapes our attitudes toward social categories, getting asymmetrically modulated by the information available to us about group dynamics. The study also looks at settings where the robust phenomenon of ingroup bias is significantly reduced, at least in a minimal group setup. The asymmetricities in responses, especially for experiments 2b and 2c, are interesting, as teasing them apart will provide insights into underlying cognitive processes of associating ourselves with a positive group as opposed to a stigmatised group in our society. Going further, these can be studied in the context of real social groups where the ingroup bias is more ingrained, and it would be interesting to see if these experimental manipulations still hold.

**Does familiarity drive the self-prioritization effects in attentional processing? Evidence from the comparison of different types of stimuli in an attentional blink task**

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In recent research, a self-prioritization effect in various cognitive processes (such as memory, perception, attention etc.) has been established with the stimuli such as self-names, self-faces andself-owned objectsetc (Suiet al.,2017). usingdifferent typesoftasks. However,the results with these stimuli have been criticised on the grounds of familiarity confounds (or over- learning) affecting the genuine self-prioritization effects. Interestingly, the robust effects have also been found when the arbitrary shapes were associated with the social labels (such as self, mother, friend, stranger) by using the associative matching tasks (see Sui & Humphreys, 2012 etc. and followingstudies).

Previously, Nijlhof et al. (2020) compared participants' performance across the attentional blink task (Shapiro et al., 1997) and the shape-label matching task (Sui et al., 2012) to check whether the self-bias observed across two different tasks was correlated, and concluded in the negative. The authors proposed that the self-bias observed across different cognitive domains as tapped through different types of task was distinct and uncorrelated. For the current study we sought to zoom in on this claim by investigating whether the self-bias observed on behalf of the participants were stable across the same cognitive task (i.e., the attentional blink task) and if familiarity moderates the same to any extent using different types of stimuli varying in familiarity (self– namesand arbitrarygeometrical shapes).We expectthat theresults fromthe current study will help in teasing apart effects of familiarity and the stability of self- prioritization effects in the same task.

Methods

We used two variations of the attentional blink task (one with self-names and another with arbitrary geometrical stimuli) which in turn had two versions :- one in which self-associated stimuli (self-name, self-associated shape) was presented as the first target, i.e., T1; and one in which the self-associated stimuli (self-name, self-associated shape) was presented as the second target, i.e., T2). Participants: We recruited two sets of 36 participants for the two experiments (with shapes) and the two (with names), based on a calculation performed using G*Power (version 3.1), as 80% power to detect a medium-sized interaction effect between Lag and Condition at alpha=0.05. None of the participants reported a history of neurological or mental health difficulties, gave written informed consent prior to the study, and were fully compensated for their participation. Different participants were used to avoid familiarity with the task and practice effects across the different tasks. The experiment was run in the Psychopy version. The study was performed in the lab setting.

Stimuli: For the first two experiments (1A, & 1B) we used 15 arbitrary shapes (more than 8 sides, RSVP streams of 14 shapes in black colour were presented to participants) and for the next two experiments (2A & 2B) we used 40 North - Indian names in Roman script, which werematched onlength, complexityetc. andincluded self-names,friend's namesand stranger names for the participants.

Task: Before we began with experiments 1A & 1B, participants performed shape-label association task (Sui, 2012) wherein the shapes of parallelogram, pentagon and hexagon were randomly assigned to the self, friend and stranger; so, that they would learn the association of the shapes with their respective labels.

In experiment 1A, participants were presented with an RSVP stream of 17 polygons in black outline, ofwhich theT1 (self,friend, orstranger associatedshape inthree differentblocks) was presented in white outline, whereas the T2 was a circle also in blackoutline. In experiment 1B, participants were presented with an RSVP stream of 17 polygons in black outline, of which the T1 could be one of the four types of equilateral triangles in white outline and T2 (self, friend, or stranger associated shape in three different blocks) in black outline.

The experiment begun with the presentation of a black fixation cross given centrally for 1000ms, andthen theRSVP streamof16 shapes(in blackcolor) werepresented for80ms each, with an ISI of 17ms. All stimuli were presented on a light grey background. The target (T1) was presented in the white color and the distractor (T2) in the black color. Notably, the T1 was presented at the 5th, 6th or 7th positions randomly; whereas the T2 could be presented at either ofthe 5 lags, i.e.,L1, L2,L4, L5,L8 afterT1. T2was presentedat eachlag 18times, atotal of 135 trials in which T2 was presented (3 (Condition) 5 (T2 Lag) x 9 repetitions). An additional trial of135 werepresented whereT2 wasabsent, resultinga totalof 270trials. Oncethe RSVP streamfinished, participantswere presentedwith 2 questionson thescreen, oneafter theother:

1. 'What was the white coloured shape? Click on the image of the shape you saw. 2. 'Was the black coloured circle present or notpresent?

In the second experiment, i.e., 1B the only difference was that the self, friend & stranger associatedshapes couldappear asthe secondtarget, i.e.,T2 and4 kindsof equilateraltriangles were presented for the T1 detection. There were 3 separate blocks for T2 conditions divided over 45 equal trials for each condition (Self/Friend/Stranger) and addition of 45 trials for each condition were presented where T2 conditions were absent. Total of 90 trials per block was presented.

Moving on, in experiment 2A, names (own name, friend's name, stranger's name) were used as the T1 in 3 different blocks. Before performing the experiment, participants were given

a shortonline googleform inwhich theyhad totype theirown nameand thename ofsomebody close to them (Friend

condition). Also, the names which of somebody close to them were excluded from a list of 40 common Indian first names. Excluded names were taken as stimuli, and one of the remaining names was considered for the stranger condition. The length of the names inall 3conditions wereof average6 alphabetslong. Finally,a namethat didnot belong to the three categories (self, friend, stranger) from the list of 40 names was selected to be presented as the second target, i.e.,T2.
The trial structure for this experiment was similar to the earlier experiments. To begin with an RSVPstream of17 nameswere presented wherein 1 wasthe firsttarget (couldbe presented at 5th, 6th or 7th positions randomly) was presented in white ink and the second target, i.e., T2 could be presented at either of the 5 lags (L1, L2, L4, L5 or L8) in black ink for 135 trials and another 135 trials where presented T2 was absent. Hence, a total of 270 trials were presented. At the end of the RSVP, participants were asked 2 questions: 1. 'What was the white coloured name? Typethe nameyou sawin whitecolour. 2.Whether theassigned another strangername present or not? Click on 'Y' or'N'.
For experiment2B, theonly differencewas thatT1 couldbe oneof thestranger's nameswhich was taken from the list of remaining names given in 40 common Indian names, and T2 would be one of the 3 name conditions (Self/Friend/ Stranger), in 3 separate blocks, leading to 90 trialswhere T2was presentand additionof another90 trialswhere T2was absent,coming toa total of 180 trials per block. Overall trails for all 3 blocks were 540.

Results
To begin with, we calculated the number of correct T1 detections for each condition and for each type of stimuli. Next, the proportion of correct T2 trials detected trials for which T2 was also correctly detected, for each lag and condition was calculated. We have also calculated the
measure oflag1 sparing,and themagnitude ofAttentional Blink.Further, wetook thedetection rates ofT2 (givencorrect T1detection) asthe dependentvariable andcomputed a3x5 repeated- measures ANOVA, with Condition (Self/Close Other/Stranger) and Lag(1/2/4/5/8).
Some interesting patterns are discernible from the observed results:

- Participants have performed best for self-associated shapes when these were presented as the T1 and also as T2|T1 accuracy, both when shapes (exp 1A, 1B) and names (exp 2B, 2B) wereused.
- Attentional blink when shapes were used as T2 (exp 1B) is almost non-existent, but is attenuated when names are used as T2 (exp 2B) asstimuli.
- Also, Lag -1 sparing is more when the self-associated names were used as stimuli(exp 2B) than self-associated shapes were used as stimuli (exp1B).

Discussion
The aim of this study was to investigate whether individuals process self-referential information differently in an Attentional Blink Task when arbitrary shapes were associated to the self, friend & stranger were used in comparison to when self-name, friend's names and stranger names were used as stimuli.
We findan interestingcontrast inthe waythe attentionalblink effectmanifests inthe twocases where thecritical stimuliare self-associatedshapes asopposed towhere thecritical stimuliare participants' own – name, a friend's name or a stranger's name.
In experiments 1A and 2A, when the self-associated stimuli (shape vs. name) are used as the firsttarget, onecan seethat inshapes' (1A)participants experienceextended lag-1 sparingthat extends uptothe 2ndlag; whilein names'(2A)participants experiencethe typicallag –1 sparing that has often been reported, but which gives way to attentional blink setting in from lag – 2 onwards, and gets better on further lags. This indicates that the use of self-associated shapes engages the participants' processing resources much more than occupied when the self- associated names were used as the critical stimuli, and as the first target.
In experiments 1B and 2B, when the self-associated shapes were used as T2, the attentional blink effect sets in as early as the first lag (no-lag 1 sparing), although the performance gets relatively better on further lags;in casewhen self-nameis usedas T2,the attentionalblink sets inonly afterlag -1,as isthe casewith typicalattentional blinkstudies andthe performancegets better movingfurther.
While moreanalyses ofthe obtainedresults isunderway, onecan concludethat self-associated shapes engageparticipants'processing resourcesto alarger extentthan theself-names, despite them latter being more familiar. More insights are expected to reveal themselves, once we are done with overall analyses and are ready to discuss them with the largercommunity.

## Can induction of creativity from a knowledge domain be transferred to a different knowledge domain?

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Introduction

Is creativity domain-specific or domain-general? Significant studies have approached this problem using self-reported personality and domain-specific and general creative ideation surveys and lack cognitive perspectives. Creativity is defined as the generation of original and useful products that have emerged through the applications of basic cognitive processes to existing knowledge structures. The current study investigates its implications while modifying the basic knowledge structure. Further, we examine the role of the knowledge domain in creative task performance. For prior knowledge structure, we used advanced Raven's matrices and modified its constraints to create a novel creative advanced Raven's Matrices (cAPM) to induce creativity. For creativity, we asked participants to perform two tasks: create Raven's like matrices using creative reasoning task (CRT) and Guilford's alternative uses task (AUT). Unlike other creativity tasks like AUT, CRT allows to measure both convergent and divergent thinking in a given task. The CRT and AUT are different from APM puzzles in two ways, i.e., the knowledge domain and the involvement of creative thinking. The fixed order of APM followed by creativity tasks allowed us to evaluate the boundaries of induced creative thinking across the knowledge domain.

Method

Participants: Total forty four students (male=24, female=20, others=0 with mean age = 19.8 years, SD = 1.7) volunteered for the study. The participants were recruited via email under course credit requirements. This is an ongoing study and we aim to collect 100 participants. But the current data is sufficient enough for statistical analysis.

Design: The participants were randomly assigned to one of the two independent experimental conditions - solving either the APM or the cAPM puzzle - each followed by the Creative Reasoning Task (CRT) and Guilford's Alternate Uses Task(AUT). Participants performed the variant of APM first and CRT and AUT task in consecutive order. The order was kept fixed to evaluate the effect of varying constraints in APM on creative task performances across CRT and AUT. The APM, cAPM and CRT tasks share knowledge domain, whereas AUT is different in knowledge domain.

Material: APM Puzzles - APM puzzle comprises a 3 x 3 matrix area with 8 response options, presented below the puzzle(Figure 1). The response options contained one correct puzzle, two most obvious errors, two least obvious errors, and three random error choices. The participant had to choose the puzzle cell that best fit the overall puzzle. The correct response was scored "1", and the incorrect response scored "0". We presented six such puzzles.

cAPM Puzzles - Creative APM (cAPM) is a modified version of the classic APM with reduced constraints. The purpose of the cAPM task was to stimulate both divergent and convergent thinking. In cAPM, the participant was provided with only a single row/column of the puzzle, along with eight options for the six empty spaces(Figure 2). The participant had to click and drag the options to the puzzle grid so that it follows the APM rules. There are multiple approaches to solve the puzzle as there are multiple ways to interpret the different rules provided in the given row/column and available options. The cAPM results were scored as "1" if all the rules from the original APM puzzle were present, and "0" if they were not. The time taken to solve all the cAPM puzzles(Median = 9 minutes, 14 seconds) is higher compared to the APM puzzles(Median = 3 minutes, 9 seconds).

Creative Reasoning Task (CRT) - During the CRT, participants were given an empty 3x3 matrix, mirroring an APM puzzle(Figure 3). The task required them to devise a complete puzzle, with the solution located in the final cell. Generating alternatives was not a requirement. The scoring methodology, as outlined by Jaarsveld and colleagues (2012), was employed to assess CRT performance. For the current study, we scored the CRT performance using the rule and relationship component excluding specification components from the total CRT scores.

Alternate Uses Task (AUT)

The Alternate Uses Task (AUT) (Guilford, 1960) is a classic test of creativity, focusing on divergent thinking. In this task, participants are asked to list as many uses as possible for a common object within a certain timeframe. The goal is to come up with unique and diverse uses for the object, pushing beyond its conventional uses. In the current study, we have used 6 items like brick and shoe. The responses are evaluated using Guilford's AUT factors: fluency, flexibility, originality,

and elaboration. For this study, fluency and elaboration scores are reported as they are not subjective with the evaluator. The fluency score is calculated as the total number of responses recorded for all the six items. The elaboration score is calculated as the summation of the total number of words for each response. The flexibility and originality parameters are subjective and multiple raters will be assigned to evaluate them and inter-rater agreement will be calculated.

Results and Conclusion

We used a threshold of 50% correct for solving APM and cAPM puzzles to ensure divergent thinking induction for creative reasoning task performance. This implies that participants are required to successfully solve a minimum of three out of six puzzles under both the APM and cAPM criteria. In CRT, we analyzed only two characteristics: the number of rules, and the relationship score between the elements (Jaarsveld et al., 2012; Arcot et al., 2023). For the AUT, we analyzed Fluency and Elaboration performance. We used the Shapiro-Wilk test to analyze the normalcy of the data and performed independent t-test and conditional Mann Whitney U test for non-parametric data.

We observed a significant effect of the variant of APM on CRT performance. Higher number of rules in the CRT was observed when it was preceded by cAPM (Median = 2, Variance = 0.59) compared to the classic APM(Median = 1, Variance = 0.27), with medium standardized effect size ($U = 394.0$, $p < 0.001$, $r = 0.58$) (Figure 4). One participant from cAPM group scored four number of rules which led to more variability in the cAPM group. Further, we observed a higher CRT Relationship Score under cAPM (Median = 78.5) compared to the classic APM(Median = 50.5) puzzle conditions, with medium standardized effect size ($U = 393.5$, $p < 0.001$, $r = 0.54$) (Figure 5). However, the variant of APM did not show a significant effect on AUT, fluency score($p = 0.8$ for independent t-test) (Figure 6) and elaboration score ($p = 0.48$ forMann-Whitney U test) (Figure 7). The current result suggests that creativity is more domain-specific than general, especially when it is about reasoning. Further, it supports previous findings (Jaarsveld et al., 2012) that show a positive correlation between SPM scores and CRT reasoning scores. In contrast, CRT creative component scores showed a positive correlation with the Test of Creative Thinking and Drawing Production (TCT-DP). However, the caveat could be discussed when the CRT creative component is analyzed along with the features of AUT task performance by evaluating the abstraction, action, and object properties. Future studies could also examine the impact of varying constraints in APM puzzles on divergent thinking tasks, like AUT, first then CRT to assess the expansion of creative thinking induction using abstract reasoning.

## Integrative processing in DNNs and biological vision predicts the perceived beauty in natural scenes

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Introduction
In our daily lives, we encounter a large variety of natural scenes. Some of these scenes appear more beautiful to us than others.Studies in empirical aesthetics revealed a set of properties (such as color, curvature, contrast, or symmetry) are associated with perceived beauty. However, we do not fully understand why such visual features explain perceived beauty. One factor that hinders progress is that we lack an understanding of overarching principles in perceptual processing that shape aesthetic preferences.
Here, we test a candidate principle for predicting the beauty of natural scenes: Does the degree of spatial integration across a scene (i.e., whether a qualitatively different whole is formed from an image's parts) constitute a computational principle that reliably predicts beauty? This idea is derived from processing fluency theories1, which suggest that computations that ease perceptual analysis are associated with an increase in perceived beauty. Interestingly, previous fMRI studies have shown that integrative processing makes sensory processing more fluent: If we can process inputs as an aggregated whole rather than many individual parts, processing becomes more efficient2. This raises the question of whether integrative processing, through an increased ease of processing, can predict perceived beauty. Here, we empirically answer this question.

Methods
We performed three experiments (N= 25, 26 and 25, respectively) in which participants were asked to rate the beauty of 250 natural scene images with brief presentation time3 (i.e., 50 ms) or with unlimited time. We then tested whether these beauty ratings could be explained by differences in integrative processing across images. We further used beauty ratings for 900 diverse natural images from the OASIS database4 to test if integrative processing still predicts perceived beauty for a wide range of photographs that depict objects, people, and everyday situations.
To quantify integration, we used a deep neural network (DNN) as a model of the biological visual system5. We used a pre-trained VGG16 network architecture trained on scene categorization using the Places365 image set. We computed integrative processing for individual scenes by feeding the DNN two halves of a scene (e.g., the bottom-left and top-right quadrants versus the bottom-right and top-left quadrants) as well as the full scene. For each scene, and separately for each DNN layer, we then computed how much the activation pattern to the full scene was correlated to the average of the activation patterns to the two halves. The strength of this correlation was taken as a measure of integrative processing, where lower values (i.e., a higher dissimilarity between the whole and its parts) indicate a higher degree of integration6. We also computed integration separately at five different spatial granularities, where halves were created by dividing the scene into 2*2, 4*4, 8*8, 16*16 or 32*32 identical squares. This allowed us to probe integrative processing at different spatial scales.
To validate whether integrative processing in human visual cortex predicts perceived beauty in a similar way as integrative processing in our DNN model, we also ran an fMRI experiment, presenting participants with whole and partial images of natural scenes. The fMRI experiment was completed by 22 participants (mean age 28.8, SD=4.5; 10 male, 12 female), butone participant was excluded. We extracted multi-voxel fMRI patterns from a set of regions in early visual cortex (V1, V2, V3, and V4) and scene-selective cortex (OPA, MPA, and PPA). We then performed an analysis analogous to our DNN analysis to quantify integration across these visual regions.

Results
Across our three experiments with natural scenes, we found a strong relationship (spearman correlation up to 0.6) between the DNN-derived integration measure and beauty ratings. This suggests that a greater degree of integrative processing increases perceived beauty. We also observed that correlations were strongest in intermediate to late network layers, suggesting that integration over mid- and high-level features determines perceived beauty. Second, correlations were apparent across all spatial scales, but strongest for the coarser scales, suggesting that integration across meaningful scene parts is a better predictor than integration over fine-grained local image elements. The integration measure predicted perceived beauty equally well for briefly presented scenes and scenes shown with unlimited presentation time.Crucially, similar results were obtained with beauty ratings from the OASIS database, despite the database images' vast variation in content and emotional associations: Correlations were lower (up to 0.22), but integrative processing still predicted beauty ratings. Our fMRI results further demonstrate that integrative processing in the biological brain can predict perceived beauty in a similar way as integrative processing in DNNs.Specifically, we found significant correlations between the degree of integrative processing in scene-selective parahippocampal place area perceived beauty. These results validate our DNN-derived measure as a good model of the brain for predicting beauty based on integration.

Discussion

This experiment establishes integrative processing as a computational principle in the visual system that is capable of explaining perceived beauty. When scenes are more strongly integrated across visual space – and consequentially, the representation of the whole gets more dissimilar to the representation of its parts – they are perceived as more beautiful. Our findings further stress the mechanistic similarity between DNNs and the human visual system and showcases the possibility to use DNNs as high throughput tools for uncovering the computational mechanisms that give rise to aesthetic appeal.

**Testing the Context-Sensitivity Hypothesis of Emotion perception using Dance Movements**

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Introduction:

Access to conceptual knowledge influences emotion categorization. Past experiments have manipulated conceptual knowledge through task (e.g. task design, language) and stimulus contexts (e.g. using posed vs. natural facial expressions)i . The present study investigated a novel stimulus context i.e. intentionality of the actor, using point-light display dance video clips and separated task and stimulus contexts using a sorting paradigm with Free vs. Anchored sortii. In Free sorting, participants sort stimuli such that individuals displaying the same emotion are piled together. In Anchored sorting, discrete emotion words are provided during sorting. We hypothesized that sorting behaviour would significantly differ under both conditions. Both stimulus and task contexts would influence sorting in the Anchored Sort, whereas only the stimulus context would influence the Free sort. Consequently, results of the Free Sort should better approximate the Intended sorting.

Method:

Participants (N = 50) were randomised by sorting condition. Both groups were matched on their participatory and observatory dance experience, with the Goldsmith Dance Sophistication Index. A norming study was used to select stimuli having the highest recognition rates from the Mc-Norm libraryiii. 10 videos were selected. Each clip (10-40s) comprised an abstract, choreographic sequence danced by the same performer with the audio stripped and the video reduced to a point-light display. The dancer intended to communicate one of the 4 emotions : happiness, sadness, neutrality, anger. Participants were asked to create and then label piles, such that the individuals in a pile were displaying the same feeling. For the Anchored Sort, emotion category labels (anger, fear, neutral, happy, sad) were also provided. The additional 'fear' label acted as a pure task context variable. The experiment was done over a desktop computer using a mouse to drag-drop clips into coloured piles.

Sorting and labelling were separately analysed. Labels were coded as movement-related, discrete emotions, affect-related or combinations. Sorting behaviour was summarized with unsupervised hierarchical agglomerative clustering. Across participants in a condition, 10 X 10 symmetric co-occurrence matrices were generated. A co-occurrence matrix contains the number of times a pair of clips are assigned to the same pile. These were converted into distance matrices by subtracting co-occurrence values from the highest possible frequency count. Using the cluster package in R, the agnes algorithm was run to output dendrograms. Similarly, with a binary co-occurrence matrix, a dendrogram was plotted for the intended case, using the dancer's pre-assigned category labels.

Results:

A 2X4 contingency table revealed a significant association between sorting condition and type of label provided, $c2 (230) = 108$, $p < .05$.Proportion of discrete-emotion terms used was greater in Anchored-sort, 0.94 > 0.28. The label "fear" occurred with 17.4% frequency in Anchored sorting but was absent in Free sorting.

A higher agglomeration coefficient was found for the Free Sort, 0.48 > 0.23. Cophenetic correlations between dendrogramsivsuggested that the Intended cluster was more similar in structure to the Free sort (rs = 0.62), than the Anchored sort (rs = 0.49).

Baker's Gamma Indexv, which is a probabilistic measure of association for the cophenetic values assigned to pairs of items, indicates whether two dendrograms are statistically similar. Its value ranges from +1 to -1, with near 0 values indicating that the clusters are not similar. The Gamma Index for Free and Anchored Sort was 0.34. The p-value (=0.02) for this statistic was obtained by running a permutation test on 100 samples. This suggested that the Free and Anchored sorts were significantly different, $p < .05$.

Discussion:

Our hypothesis regarding dissimilar sorting behaviour between groups was corroborated. In the Free Sort, perceived similarity between items was greater than in Anchored Sort – hence, clustering was more distinct and better separable into intended categories. To ensure that the task context explained the dissimilarity, rather than confounds in group sampling, clustering would need to be validated by bootstrapping. Controlling for the word-anchored sort with number and video-anchored sortsvicould also be incorporated.

Conceptual access in Anchored sort contributed to the dissimilarity, as demonstrated by free-labelling results. Under the constructionist view of emotions, affect-based categorization is said to be universal as it does not require culturally relative emotion conceptsvii.Establishing high perceptual variability through motion-energy analysis of the PLD stimuli would suggest the use of goal-based emotion concepts to generate categories in the task. This would explain the higher correlation of Free sort and Intended clusters, indicating that both categorizations were affect-based. The theory of rasadharma-s found in Indian Aesthetics, may further explain how 4 universal affect categories can be expressed and perceived in non-representative dance.

# POSTER PRESENTATION ABSTRACTS

## Poster Session 1

### Anticipatory Mechanisms in Peri-hand Space Slows Down Subjective Experience of Time

Maurya, Ankit*; Thomas, Tony ; Shukla, Anuj
*Department of Humanities and Social Sciences, Indian Institute of Technology Roorkee*

Introduction:
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## Schizophrenia and auditory hallucinations through the lens of predictive failures

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Background: Context-driven prediction error signalling entails recognizing and predicting regularities in one's environment and eliciting surprise when such predictions are violated. Action-driven prediction error signalling involves modulation of the brain's motor and sensory areas in sync such that action generated by self-versus-others are correctly distinguished. Dysregulated Prediction error-signalling (PE) can elucidate the pathophysiology of auditory hallucinations (AH) in schizophrenia (SZ)1.

We examined (a) Context-driven prediction error signalling using robust roving mismatch negativity (rMMN) paradigm2 and (b) Action-driven prediction error signalling with corollary discharge index (CDI)3 in schizophrenia patients with persistent auditory verbal hallucinations (SZ-AH) and healthy controls (HC) with event-related potential (ERP) paradigms. We also examined whether rMMN and CD indices were modulated by add-on treatment with accelerated transcranial direct current stimulation (acctDCS) SZ-AH patients.

In roving mismatch negativity (rMMN), the deviant tone becomes the new standard with repetitions. Longer repetitions yield stronger sensory-adaptation response—Repetition Positivity (RP). Longer repetitions elicit a stronger deviance-detection when interrupted—deviant negativity (DN) and effect stronger prediction-error signalling—mismatch negativity (MMN)2.

In corollary discharge (CD) ERP paradigm, the ability to suppress sensory consequences of self-generation action is assessed by contrasting auditory-response to self-generated-speech during vocalization (N1Talk) with auditory-response to passive-playback of self-generated-speech (N1Listen). Additionally, Corollary Discharge Index (CDI), that is, the degree of suppression of sensory consequence from CD phenomenon during speech generation relative to listening, was determined by subtracting N1Listen amplitude from N1Talk amplitude3.

AcctDCS works on the same principles as conventional transcranial direct current stimulation (tDCS). In an acctDCS protocol, a greater number of sessions are administered over a shorter duration to facilitate a rapid induction of short-term neuroplasticity with neuromodulation4,5.

Methods: 23 SZ-AH patients (Age=33.96±9.54; 12 females) and 23 HC (Age=28.70±4.62; 7 females) participated in the rMMN experiment6 where several types of standard stimuli varying in both pitch & duration were repeated in sets of 3, 8, 33 yielding three levels for each of the three components: RP (RP3, RP8, RP33), DN (DN3, DN8, DN33), MMN (MMN3, MMN8, MMN33) measured at Fz. 31 SZ-AH patients (Age= 32.74±9.57; 15 females) and 32 HC (Age= 27.81±3.68; 8 females) participated in the CD experiment. N1-Talk and N1-Listen amplitudes were elicited using a standard Talk-Listen paradigm as per previous descriptions and reported at Cz. Amplitudes and latencies were compared between SZ-AH and HC. The correlation test examined the potential association between ERP indices and clinical variables in SZ-AH, RP-DN pairs for 3,8 and 33, and CDI. Additionally, thirteen SZ-AH patients received acctDCS treatment of persistent AH as per standard procedures. Eleven SZ-AH patients underwent both pre-acctDCS and post-acctDCS assessment of rMMN. Thirteen SZ-AH patients completed both pre-acctDCS and post-acctDCS assessment of CD.

Results: SZ-AH had preserved RP amplitudes ($F_{3,42}=0.54$, $p=0.98$, partial $\eta^2=0.004$), but significantly lower DN amplitudes ($F_{3,42}=3.31$, $p=0.03$, partial $\eta^2=0.19$). SZ-AH had diminished DN3, DN8, and DN33 amplitudes compared to HC. Though a significant effect of group type was noted ($F_{3,42}=3.10$; $p=0.04$; partial $\eta^2=0.18$) for the combined MMN variables (MMN3, MMN8, MMN33), this effect turned out to be significant only for MMN33 ($F=7.97$; $p<0.01$; partial $\eta^2=0.15$). Furthermore, only MMN33 latency was significantly deficient in SZ-AH compared to HC ($U=379$; $p=0.012$). Additionally, in SZ-AH, the link between repetition-dependent sensory adaptation (RP) and deviance detection (DN) was compromised and contrary to HC (Table 1). Also, a higher frequency of AH was associated with more positive RP3, RP33 amplitudes. Taken together, these findings suggest that though the RP profile (RP3<RP8<RP33~increasing positivity) is intact in SZ-AH, it likely indicates a hyper-attenuation to internal percepts and a sub-optimal auditory processing capacity rather than preserved repetition-dependent sensory adaptation6.

In SZ-AH, the N1-Talk and N1-Listen amplitudes did not significantly differ from each other ($z=0.41$; $p=0.68$), unlike HC ($z=3.20$; $p=0.001$). SZ-AH also showed significantly suppressed CDI compared to HC ($z=2.00$; $p=0.003$), indicating that though functional, CD is suboptimal in SZ-AH (Figure 1). The N1-Talk and N1-Listen latencies did not significantly differ from each other for SZ-AH and HC.

All SZ-AH patients tolerated acctDCS treatment well, and none reported any side-effect. A significant reduction in AH score was noted from pre-acctDCS to post-acctDCS time point ($t=5.73$; $p<0.001$). The percentage (Mean⊠SD) reduction in the severity of AH was 21.27±11.61. With acctDCS treatment, SZ-AH showed significant correction in the CD profile (Figure 2) and a trend towards correction of the rMMN profile (Figure 3).

Conclusion: SZ-AH showed suboptimal context-and-action-driven PE signalling compared to HC, as indicated by dysregulated rMMN profile, and suppressed CDI. CD and rMMN deficits can be potentially corrected with left front-temporoparietal acctDCS protocol for treating AH in schizophrenia. This is the first multi-subject study supplemented with neurophysiological evidence to support the safety, tolerability, and potential clinical utility of acctDCS for treating persistent AVH. Superiority of acctDCS over conventional protocols merits further evaluation with a randomized-sham-controlled design and replication with a larger sample size.

**Functional depth vision of one-eyed individuals cannot be completely recovered by monocular depth cue**

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Introduction: The presence of two horizontally displaced eyes in humans creates binocular retinal disparity for calculating 3D depth information [1]. This, combined with monocular cues, like motion parallax, relative size, etc., creates a veridical representation of depth that allows us to perform our activities of daily living [2]. Of these depth cues, retinal disparity and motion parallax provide quantitative depth information while other cues supplement this experience by providing ordinal depth information [2]. Human beings are thought to derive the final depth estimate of an object from a weighted average of these depth cues, with the retinal disparity cue derived from binocular parallax accorded the maximum weightage owing to high precision in providing depth estimates [2]. While habitual viewing is binocular, permanent loss of vision in one eye (henceforth, referred to as uniocular viewing) may occur in humans owing to a variety of reasons including trauma, disease, etc making retinal disparity absent. Such uniocular individuals have to then rely only on monocular depth cues for performing their day-to-day activities. While these individuals reporting to the clinic complaints of difficulties with depth-related dexterity tasks, like pouring water from a jug onto a glass, inserting a key into the keyhole, etc., there are anecdotal instances of cricketers like Nawab Mansur Ali Khan Pataudi, who lost his right eye at the age of 20 due to trauma but successfully played international cricket and was then adjudged to be the “best fielder in the world” [3]. Instances like this raise the question of whether the monocular cues to depth have “sharpened” in the absence of retinal disparity, similar to the way other senses (e.g., auditory) get “sharpened” upon losing eyesight [4]? The present study addresses this issue by asking the following questions: 1) Do extended periods of uniocular viewing make individuals any better in functional depth vision tasks, relative to binocular and monocular viewing of age-similar controls? 2) Does their performance depend on the age and/or duration of uniocularity? 3) Do head movements facilitate the use of monocular cues like motion parallax in deriving depth information?

Methods: Functional depth vision was tested using the buzz-wire game in 46 uniocular subjects [median (min-max) age: 23yrs (7-37yrs)] and 46 age similar binocular controls [24yrs (6-36yrs); p=0.78]. The buzz-wire game serves as a prototypical, functional, depth-vision task, in which subjects navigated a circular hoop around a wire without touching it. In case of a contact, a buzzer sounds and the subject needs to re-center the hoop around the wire to move forward [5]. Depth modulation in slant and curvature was created for three buzz-wires. Sample size of 24 subjects was calculated using G*Power software. Subjects performed all three buzz-wire tasks, with and without head restraint, all in random order to minimize learning. The performance of uniocular subjects was compared with the binocular and monocular viewing of controls. Performances were video recorded and analyzed offline to determine the two primary study outcomes: 1) frequency of errors, which reflects how often the hoop came in contact with the wire per second, and 2) error-adjusted time, which reflects the time to complete the task, minus the time spent in error.

Results: The mean (±SD) frequency of errors of the uniocular subjects [0.32 (±0.10 errors/sec)] was similar to the monocular viewing condition of the controls [0.35 (±0.10 errors/sec); t=1.53; p=0.13; Bayes factor for null hypothesis H0 over alternate hypothesis H1(BF01)=7.42], but significantly worse than their binocular viewing [0.17 errors/sec (±0.12 errors/sec); t=-6.90, p<0.001, Bayes factor for H1 over H0 (BF10)=29110]. No evidence was found for head restraint on the frequency of errors with the uniocular viewing [0.34 (±0.10) errors/sec, t=-1.50, p=0.14, BF01=2.14], or with monocular viewing of controls [0.37 (± 0.89) errors/sec, t=-1.52, p=0.13, BF01=2.40]. The error-adjusted times of uniocular participants [34.16 sec (±13.57 sec)] was similar to the monocular viewing of controls [32.62 (±13.03 sec); t=-0.56, p=0.58, BF01=5.56], but longer than their binocular viewing [24.23sec (±9.32sec), t=-4.09, p<0.01, BF10=127.53]. A multiple regression analysis did not found a significant impact of age and duration of uniocularity on frequency of error, while younger participants in both cohorts made more errors than adults.

Discussion: Performance in a complex functional depth vision task remains deficient (longer time with higher errors) in one-eyed individuals, suggesting that monocular cues are unable to substitute for the absence of retinal disparity. The age and duration of uniocularity does not seem to impact task performance in uniocular individuals, suggesting that it has little bearing on their ability to engage in dynamic functional depth vision tasks. Also, these individuals did not seem to make any remarkable head movements to facilitate the use of monocular depth cues for performing the task. This may be attributed, in part, to the dynamic nature of the task, where the subject needs to move the hoop, thus restricting them from making head movements. Future studies are aimed to explore the role of motion parallax in depth perception and efficacy of monocular cues for depth perception in static tasks.

# A Neuroconnectionist Approach to Investigate Spatial Prepositions 'Far' and 'Near' Using Visual Input

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Introduction

We live in an intricate three-dimensional environment in which we must navigate, perceive our surroundings, and establish our position and the positions of other objects around us. Vision plays a significant role in navigation compared to other sensory inputs. Depth perception in visual scenes relies on multiple cues. Binocular cues involve the disparities between the visual information each eye receives (binocular disparity) and the eyes' convergence when focusing on nearby objects. Monocular cues encompass linear perspective, texture gradient, shadows and shading, motion parallax, accommodation, areal perspective, relative height, and occlusion. By incorporating these cues, humans can perceive and estimate depth in their visual environment (Snowden et al., 2012, Wade and Swanston, 2013). After perceiving a visual world, we employ linguistic expressions to communicate our observations to others. These linguistic terms serve as a means of conveying the spatial information we have perceived and enable us to effectively communicate the spatial relationships of objects within the visual scene. Sensory experiences gathered over the background of a spatiotemporal world are used as the raw material to create more abstract concepts (Hagoort, 2022, Tyler and Evans, 2003). For example, when we speak of gaining a deep understanding of a subject, we borrow a spatial concept and superimpose it on an abstract concept. Spatial semantics is the study of spatial expressions, that is, conventional specifications of the location or change of location of a given entity (Zlatev, 2010). Spatial prepositions are one such syntactic category that encode the structure of physical space. They are small in number and are a closed class in any language (Talmy, 1983). This gives an insight into our mental representations of space and spatial relationships. The relationship between the visual space and the spatial preposition it represents is modeled. Analyzing spatial prepositions using a deep neural network trained by views of a 3D environment offers a valuable understanding of the synergy between space, cognition, and language. Convolutional Neural Networks (CNNs) have demonstrated excellent capabilities in visual pattern recognition (Doerig et al., 2023, Jacob et al., 2021, Khaligh-Razavi and Kriegeskorte, 2014).

Methods

Synthetic image datasets are generated by taking views of a single object placed in a virtual 3D environment (Figure 1). In one set, the objects are grounded, meaning all the objects in the images are generated by placing the object in a single horizontal plane. In another, the objects are ungrounded, i.e., not confined to a plane. Only one object is present within the scene at a time. The object can be of various shapes, sizes, and colors. A CNN is trained to classify the object in the scene as far or near based on a set distance threshold (Figure 2). The training data comprised 24,000 images; testing and validation contain 3000 images each.

The effect of camera height on far/near classification is also considered. The choice of spatial semantic terms far and near is made as they explicitly convey distance from the viewer (Carlson and Covey, 2005). The threshold between far and near is varied for further studies. To study the effect of camera height, five grounded datasets are generated where the camera location along the vertical direction is varied. With no other perceptual clues and with only one object present at a time, it is impossible to estimate the depth at which the object is. The study aims to find how the constraints of the real world enable us to answer this question. It also looks at how well a CNN performs on this task, given that the only information it gets about the object's distance is whatever it can extract from the image.

Results

The network is expected to perform poorly in the task due to the lack of background clues. The images do not directly indicate the actual size of the objects. This is because the size perceived in the image is influenced by two factors: the actual size of the objects and their distance from the camera. In the datasets, objects with the same shape and color can vary in size, which makes size an insufficient clue for determining distance. The average accuracy (across all thresholds) for grounded cases is 98.86%, and for ungrounded cases is 82.94% (Figure 3). The classification accuracy for different categories of size, shape, and color for grounded and ungrounded cases shows that it is invariant to shape and color. The size of the object influences the accuracy. The accuracy is lower when the object is small, increases with size, and then drops. Small objects tend to make higher errors because, at a distance, fewer pixels represent the object in the image. Larger objects also make more errors as the distance between the object's center (w.r.t, which far and near is defined) and the object's face (towards the camera) is great. The spatial locations where the network makes errors are shown in Figures 4 and 5.

Discussion

The task of determining the distance of an object from individual images in the dataset is challenging. Still, the network performance shows that it can classify to a certain extent based on the spatial constraints placed on the image generation process. The performance is extremely good for the grounded case, demonstrating that the problem of far/near classification is well-defined for grounded objects, given that the camera is sufficiently high. The difference in the network's performance between grounded and ungrounded cases can be explained using the physical properties of the retinal imaging system. When the objects are confined to a single plane, the accuracy is higher as the depth information (along the z direction) gets linearly projected onto the retinal plane along the y direction (Figure 6).

In the grounded case, when the camera height was lowered, the accuracy decreased (Figure 7). Insights can be gained into visual illusions observed in photographs lacking reference points, such as those taken at Salar salt lakes (Buggles, 2013,p. 6). These illusions result in the perception of objects (or people) appearing smaller than their actual size due to our inability to perceive the depth at which the object is placed. Size constancy is a perceptual phenomenon where objects are perceived to have a consistent size, regardless of their distance from the observer (Sperandio & Chouinard, 2015). It involves estimating the distance at which the object is and compensating for it.

It allows us to accurately perceive and interpret the size of objects in the external world despite changes in their retinal image size as they move closer or farther away. Lowering the camera's height and bringing it closer to the ground plane makes depth perception difficult, giving a false impression of relative distance. With no background clues, the images tend to deceive the human eye. The network's learning process sheds light on the underlying mechanisms behind this visual illusion observed in human vision. Specifically, it suggests that lowering the height of the camera and strategically obscuring the base of the object in the background can enhance the perceptual effect of size reduction in comparison to objects in the foreground.

# Facial Features and Gender Identification: Assessing the influence of internal and external facial features in gender identification among known and novel faces.

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Introduction

Faces are one of the most important stimuli used to convey a plethora of socially and evolutionarily important information (emotional states, Identity recognition etc.) among humans. Aiding gender identification is yet another important role played by faces. Human Faces are comprised of External (Hair, face outline, Ear placement, Neck etc.) and Internal features (Eyes, Nose, Mouth etc.). Studies have been done, gauging the influence of these external as well as internal features on facial identification.

Faces have been seen to show striking differences between sexes. Female faces are only about one-fifth of the male and female noses are also proportionately smaller and wider with respect to males (Brown & Perrett, 1992). Studies have shown that configurational cues regarding the spatial locations of internal facial features such as eyes, mouth and nose with respect to external facial features such as facial outline, hair etc. gives sufficient cue for gender identification (Haig 1984). Individual facial features do carry information about sex. The male and female versions of each facial part, except for the nose are seen to carry gender-specific information. Among these facial parts, the eyes are seen to carry more information regarding gender (Brown & Perrett, 1992).

As mentioned earlier Human faces are the amalgamation of external (Hair, Face outline, Neck, Ear placement) as well as internal (Eyes, Mouth, Nose) features. Studies have found that external features are not presented in the same neural system as the internal features. External feature representation has been found to happen in the face-selective cortex in the brain (Liu et al.,2009). It has been found that the Occipital Face area (OFA) and posterior superior temporal sulcus (pSTS) are seen to represent the parts of internal features whereas the Fusiform Face Area (FFA) represents the coherent arrangement of internal features (Pitcher et al., 2007). This finding has been further validated by further studies that showed FFA is critical in discerning internal facial features (Ewbank & Andrews, 2008; Mazard et al., 2006) It was seen that as the familiarity of a face increases the reliance on internal features becomes more for face recognition (Donnell & Bruce, 2001)

Bruce and Young (1986) have identified separate pathways used in facial processing. One is used to identify the person whereas the other pathway discerns the age, sex and race of that face.

AIM: The main aim motivating the current study is to analyse the influence exerted by external facial features such as Hairline, face outline etc and internal facial features such as eyes, nose and mouth on the sex identification of an individual. It further attempts to probe whether the same influence is exerted by these facial features for sex determination of a known face (Eg. Celebrity faces) in comparison to unknown faces. find the influence of external and internal facial features on gender identification between unknown and familiar faces.

Methods

Design: The study Uses a 2 (Known vs. Unknown) X 2 (External features vs. Internal features) within-subject design.

Stimuli:The participants will be exposed to Novel ambiguous facial stimuli created by merging the internal facial features of an unknown female with the external facial features of an unknown male and vice versa (Internal facial features of an unknown male with external facial features of an unknown female). The same process will also be used to make novel facial stimuli from known faces. The extent of internal and external facial features will be manipulated to determine the extent of their impact on sex identification. Participants will be asked to identify the sex of these stimuli. The response time as well as the identified sex rates will be catalogued for each novel stimuli.

Tools: The experiment was created in Opensesame experiment creator. It's a free, online cross-platform created for creating experiments in psychology. The images were edited in Photopea software.

Participant:- A sample space of 90 (Effect size = 0.4, power = 0.95) participants is scheduled to take part in the study.

- inclusion criterion: -
- Normal or corrected to normal visual acuity.
- Falling under the young adult age category of 18-32

Methodology: Unknown faces for the study were taken from the American Multicultural Face Directory (AMFD), which is a free database comprising 110 standardised human faces (Chen et al., 2021).As for known faces, since there is an absence of a standardized face directory, online images of famous personalities were taken and standardized before being used for the experiment. Images were standardized to 512 X 600 pixels. Uniform image features such as contrast, hue, saturation etc was normalized across the images.

Unknown as well as known faces were merged in the below-said format; Female internal features were merged with male external features and male internal features were merged with female exterior features. Extra care was given to remove external characteristics that could potentially give way to gender identity such as ornaments etc. internal features of the merged faces were altered (just eyes shown, just nose shown, just mouth shown etc.) as well as in order to see if skin tone influenced gender perception, the images were transformed to negatives.

The participants were asked to identify the gender of the images shown in various characteristics. Their responses and response timings will be recorded and analysed.

Rationale: mixing the facial features of the opposite sex to create novel stimuli (which for the participant is a unique facial stimuli, that they have to guess the sex of) helps in discerning the impact the internal and external feature of a face has on sex determination. When a novel stimulus is created using the external features of a male face and internal features of a female face, and the face is perceived as a male, then it can be logically deduced that the external features of the novel stimuli (coming from a male face) influenced the sex perception of the face. If the novel stimuli is perceived as a female then it can be deduced that the internal features of novel stimuli (coming from a female face) influenced its sex perception. The extent of internal and external features will also be manipulated (E.g. omitting eyes, nose, mouth, colour inversion etc) to assess the influence that each individual facial feature has on sex determination.
Analysis: participants' perception of whether the novel stimuli was male or female were recorded in response time taken by the participants to arrive at this decision. The sex percentages perceived by the participants for each stimulus shall be compared to find the influence of internal and external facial features on sex determination.

- Expected Results

The study is in its ongoing phase. Data collection is proceeding as per the timeline and is expected to be over within this month. The following results are highly likely to be expected from the previous literature.

- Increased reliance on internal facial features for ‘identity recognition’, with the increase in the familiarity of the face, the collected data could potentially point fingers towards a significant difference in the cognitive usage of external and internal features for ‘Sex determination’ between unknown and familiar faces.
- The possibility of the participant's sex influencing the results can also be explored.

Discussion

Human faces comprise external as well as internal facial features. Studies have found that there exist different pathways in the brain analysing the internal as well as external facial features differently. It has also been found that there exist different pathways to process known as well as unknown faces. In fact, it has been seen that there is a high right hemispheric lateralization in processing unknown faces. In light of these findings, it is highly likely that humans may differentiate between the external and internal facial features in identifying the sex of known and unknown faces.
With increasing familiarity with a face, it has been shown that people rely more on internal facial features in order to identify the face. In that context, it can be logically expected that the sex of the known faces (merged) will be identified using internal facial features. Thus, when the internal facial features of a known female is merged with the external facial feature of known males, it is highly likely that the new facial image will be recognised as female and vice versa.
The current study attempts to find the influence of external vs. internal facial features on the Sex identification of known vs. unknown individuals. The collected data is expected to shed light on the same.

**Temporal dynamics of human perceptual averaging using a neural network model**

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Computing summary or ensemble statistics of a visual scene, or perceptual averaging. is often automatic and a hard necessity for stable sensory life of a cognitive agent. Although computationally the process should be as simple as applying a filter as it were to a perceived scene, the issue of mechanism of summary statistics is complicated by the fact that we can seamlessly switch from summarizing to individuation while computing the ensemble averages across multiple reference frames. In the current work we have investigated the possibility of a neural network that can also switch between individuation and summarization. We have chosen a computational model previously used for enumeration/individuation in order to show possibility of extracting summary statistics using two different measures from the network. The results also shed a light on possible temporal dynamics of ensemble perception.

## Effect of colour on eye movements in high anxiety

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Introduction:

Anxiety is one of the prevalent disorders affecting 33.7% of the world's population [1]. It is an emotional state of anxiousness accompanied by cognitive and physiological changes. This state is manifested as a clinical symptomatology of F40 – F48 (ICD-11, 2019) or a pervasive personality disposition of "trait-anxiety" [2]. In both the cases, attention is compromised as in more attentiveness towards threatening stimulus or withdrawal from it [3]. Fixation based eye parameters have evidently being useful in understanding attention in human subjects [4].

Images with form have its own connotations connected with one's past experiences and this is predominant in the visualization process to map and relate to one's schema. Abstract images lack such direct relevance from past experiences so how one responds to it is totally novel and idiosyncratic. Previous studies have suggested a link between personality traits and colour preference [5]. Individuals with high anxiety preferred less saturated shades over pastel colours [6]. In a classic study on effect of colour, it is seen green appeared to improve anxiety symptoms while yellow appeared to improve depressive symptoms [7].Hermann Rorschach, himself stated that colour response helps in understanding one's affectivity [8]. Rorschach InkBlot Test (RIBT) cards are such standardized ambiguous images developed with different colour hues to elicit affective responses [9].

In the present study, the aim is to explore if there are any significant differences in eye movement behaviour between individuals with high and moderate trait anxiety when they are exposed to stimulus of different colour hues.

Methodology:

The study started after taking clearance from ethical committee of the institute. Purposive sampling was followed to recruit 26 university students within the age group of 21-30 years (Mean: 26±5). Licensed clinical psychologist supervised the clinical session of test taking. Trait anxiety was assessed using the State-Trait Anxiety Inventory that has two separate forms which are reliable and valid measures of state and trait anxiety. In the present study, Y2 form which indicate trait anxiety with level of severity helped in segregating highly anxious participants from less anxious ones.

Participants with high trait anxiety were labeled as 'Anxious group' and moderate trait anxiety as 'Control group'. Participants were shown three RIBT cards - I: monochromatic, II: dichromatic and X: polychromatic cards. Cards were displayed on 21-inch monitor and asked to state what they saw. These cards were shown in two phases as per Klopfer protocol of conducting RIBT. The eye measures were recorded simultaneously and test-retest was also met using the same protocol. Tobii Eye Tracker(X3-120)was mounted on the screen where the cards were displayed during the test. Audio-visual recording of participants responses were also captured using web cam (Logitech 720p) for further validation. Different regions of the Inkblots were marked as location markers according to Klopfer's protocol [10]. These regions are used as AOIs for computation of the eye parameters. Statistical treatment using t-test was carried out to find if there are any significant differences between the groups.

Results and Discussion:

The following eye parameters as mentioned in Table 1 were found to be useful in significantly differentiating the two levels of anxiety groups while visualizing cards of different colour hues (Table 1).

The findings reveal mean difference of 12.99 and 12.21 for FC and VC, respectively in card I – monochromatic card and this is highly significant in terms of eye movement behaviour to distinguish the two groups. This might be because less saturated cards are less threatening to look at and arouse less affectivity [5]. The difference in fixation-based eye parameters between two groups in their visualization of Card 1 is shown below (Figure 2).

Conclusion:

Significant differences in eye movement behaviour were observed between the two groups when presented with three cards with different colour hues. Card I, which is the monochromatic RIBT Cards have higher potential to objectively differentiate high trait anxiety from moderate trait anxiety group. Future studies are warranted to establish the diagnostic validity of chromaticity in RIBT Cards.

## The Effect of Indian Classical Music on Sustained and Selective Attention

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Introduction:

Music has a positive effect on cognitive functions (Rickard et al 2005) and attention is one of the primary cognitive functions required to perform any task. This paper mainly focuses on sustained and selective attention. According to a study conducted by Mammarella et al., in 2007 proved that individuals who were listening to music in the background performed better in attention tasks than individuals who were not listening to any music.

The tempo of the music was one of the factors that was taken into consideration as according to the study conducted by Lee and H, (2015) it was found that different pitches also played an important part as children who were listening to low-pitch sounds performed better than children listening to high pitch sounds. This implies that factors such as pitch and tempo have an effect on attention performance.

The main purpose of this paper was to study the effect of background music on sustained and selective attention. Another aspect that this paper tried to understand is whether factors like the tempo of the music made any difference in the performance of attentional tasks.

Methodology:

Google form link was sent to potential participants, they filled out their demographic details and General Health Questionnaire- 28 (GHQ-28). Out of 94 participants who filled out the form, 4 participants were excluded from the study as they had high GHQ scores.

The participants were divided into three groups evenly- Group 1 (control group, no background music), Group 2 (slow-tempo music), and Group 3 (fast-tempo music). To assess the baseline level of sustained attention and selective attention among participants, the pre-test and post-test experimental method was chosen. To assess selective attention the Stroop test was used and Mackworth's clock test was used to assess sustained attention. These tests were conducted through software called PEBL.

For the pre-test, participants performed the Stroop test and then there was a 5-minute break and then participants performed the Mackworth's clock test, which was followed by a 10-minute break. After the 10-minute break-

Group 1 received no background music – they performed the Stroop test and the Mackworth's clock test again with a 5-minute interval in between. There was no music or added noise present while they were performing the tests.

Group 2 listened to slow-tempo music in the background while performing the Stroop test and Mackworth's clock test again with a 5-minute interval in between. This group was listening to the music in the background through the laptop speakers, the amplitude of the music was kept low.

Group 3 listened to fast-tempo music in the background while performing the Stroop test and Mackworth's clock test again with a 5-minute interval in between. This group was listening to the music in the background through the laptop speakers, the amplitude of the music was kept low.

Results:

A non-parametric ANOVA was conducted and there was a statistically significant difference between the Stroop test performance and between the pre-test ($H= 2.83$, $p= 0.307$) and post-test ($H=11.73$, $p= 0.003$). The incongruent RT was used for the analysis of selective attention. A post hoc pairwise comparison was conducted on all three groups for the selective attention task and it was observed that there was a significant difference in Stroop test performance in Group 1 and Group 2 ($p=0.0015$) and Group 1 and Group 3 ($p=0.005$) but there was no significant difference between Group 2 and Group 3 ($p= 0.948$). There was no statistical difference in performance between groups listening to fast-tempo music and slow-tempo music. A non-parametric ANOVA was conducted and there was a statistically significant difference between Mackworth's clock test performance and between the pre-test ($H= 9.99$, $p= 0.007$) and post-test ($H=16.60$, $p< .001$). The correct responses were selected in the analysis of sustained attention performance. In the post hoc pairwise comparison, it was observed that there was a significant difference in Stroop test performance in Group 1 and Group 2 ($p< 0.001$); and Group 1 and Group 3 ($p=0.004$) but there was no significant difference between Group 2 and Group 3 ($p= 0.998$). There was no statistically significant difference in performance between individuals listening to fast-tempo and slow-tempo music.

Discussion:

In conclusion, Groups listening to music while performing tasks performed better than those who did not. Improvement in performance was seen in the control group as well due to the practice effect, however, the improvement was more significant in the experimental group. The reaction time was reduced in groups listening to background music and hence performed better in the Stroop test. According to the results, fast-tempo music helped reduce reaction time better than slow-tempo music (see Figure 1). However, in Mackworth's clock test, Group 2 had fewer errors compared to Group 3 (see Figure 2), as a faster reaction time can also result in more errors. Hence according to the results, music can be used as an intervention to improve attention difficulties. Further studies can examine how music helps in improving cognitive functions.

**The ageing heart : changes in the cortical representation of the heartbeat across lifespan**

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Introduction :

The brain continually receives signals from both our internal body and the external environment. Among its essential roles, the brain is responsible for upholding homeostasis by processing these visceral signals, even during periods of rest—this phenomenon is referred to as interoception. For example, the signal of our heartbeat triggers a cortical-level heart-evoked response (HER), impacting a range of psychological and cognitive functions. As ageing is linked with cardiac dysfunction [3] and alterations in brain rhythm characteristics [7], there is growing interest in exploring the ramifications on heart-brain dynamics, making it a subject of extensive scientific investigation.

Methods :

To address the above question, we used data from Cambridge Centre for Aging and Neuroscience (Cam-CAN) repository of participants aged between 18-88 (mean = 47.67, SD =±16.27) years. Six hundred twenty participants (female = 49.52%) were part of this study and in the process of experiencing healthy aging. In the resting state acquisition [2], the participants were asked to close their eyes for 8 minutes 40 seconds and simultaneous magnetoencephalography (MEG) and electrocardiogram (ECG) were recorded. ECG time series was considered as a temporal trigger to epoch the MEG (artifact free; sensor level) time series 200 ms prior to the R peak and 800ms post the R peak. We calculated the HERs by averaging epochs across trials and channels. To investigate the mechanism of the generation of HERs, we analysed inter-trial phase coherence (ITPC) and examined time-frequency spectral power using wavelet transformation. Moreover, our aim was to probe the causal connection between the heart and the brain (source level), hence we utilised Granger causality (GC). To ensure the reliability of our approach, we conducted a validation check by generating pseudo time series through shuffling the ECG time series (simulated ECG time series).

Results :

In our analysis of HERs at the sensor level, we observed a distinct time-locking of the amplitude to the 180-320 ms post R peak of the ECG. Additionally, we identified a clear declining trend in the peak-to-peak amplitude of HERs with age (r: -0.1963; $p < 0.001$), indicating age-related changes in how the cortex represents the heartbeat. We aimed to substantiate the theory that the heartbeat affects spontaneous brain activity primarily through phase resetting, rather than introducing additive alterations in spectral power. Intriguingly, we found a significant increase in ITPC at 180-320 ms post R peak, contrasting the absence of time-locked activity in the time-frequency spectral power across all age groups. Furthermore, we observed a noteworthy increase in ITPC values with age within the theta (4-8 Hz; r: 0.2236**) frequency range. The neural origins of HERs encompassed the orbitofrontal cortex, anterior cingulate cortex, as well as the temporal and frontal cortex across all age groups. In our effort to establish a causal relationship between the neural and cardiac systems, Granger causality analysis unveiled a significant flow of information from the brain to the heart (Young: 0.081**, Middle: 0.078**, Old: 0.078**), while the reverse direction, from heart to brain, was deemed insignificant. This underscores the top-down influence of the brain on cardiac function.

Discussion :

In this study, our primary goal was to investigate how the cortex represents the heartbeat during the resting state, particularly focusing on age-related variations, as the resting state offers insights into homeostasis. Our objective was to uncover the neural origins and mechanisms contributing to HERs in this resting state. The decline in HERs observed across different age groups could be interpreted as a diminished sensitivity of the central nervous system with advancing age. This reduction may be associated with a decrease in cortical thickness influenced by white matter atrophy, as suggested by [6]. Moreover, analysis of ITPC in our dataset implies that the heartbeat serves as an internal stimulus resetting the phase without an increase in spectral power time-locked to the R peak of the ECG waveform, in line with the observation made by [4] in epileptic patients. Our GC analysis revealed a significant influence from the brain to the heart across all age groups, while connectivity from the heart to the brain was not significant. These results underscore the notable role of top-down brain signals in regulating cardiac activity and indicate a potential correlation with various cognitive functions [1,5]. Collectively, HERs could serve as a promising biomarker for exploring heart-brain interactions that play a crucial role in governing several essential daily functions.

**Distortions in Implicit Hand Representation of Congenitally Blind**

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Introduction:

In order to estimate the accurate location of touch on the body part, humans must integrate information from multiple sources and afferent modalities; the position of the limb in space is given by receptors from joints measuring joint angles, muscle spindles measuring flexion or extension of the muscles, efferent copy from motor commands and to extent from the skin stretch information in the somatosensory system. This incoming sensory information must be integrated with the metric information like the size and shape of the body parts, which is not directly provided by any sensory afferents. This requires an internally stored information about the body metrics, which is defined as “body model”. This body model is shown to be distorted. A series of studies investigating the body model of the hand using localization tasks has consistently shown that the participants underestimate their finger lengths and overestimate their hand widths (Longo & Haggard, 2010, Longo & Haggard, 2012a). Several studies have demonstrated that the visual awareness of size of body parts plays a crucial role in judging distances on body parts and estimating object sizes on body (Bruno & Bertamini, 2010; Taylor-Clarke et al., 2004; Longo & Haggard, 2012b). Given the involvement of visual and kinesthetic sensory modalities in estimation of body model, we investigated the role of early vision in the formation of this body model. We studied the implicit hand representation in Blind(B), Blind folded(BF) control and sighted(S) control.

Methods:

A total of 90 participants took part in the study. Thirty visually impaired participants (1 female, mean age = 22.25) including congenital and late blind. Two groups of normally sighted participants served as controls. Thirty participants (12 females, mean age = 21.4) performed the experiment in blindfolded condition. Thirty participants (14 females, mean age = 20.85) performed the experiment without the blind fold making it a total of three groups i.e. Blind(B), Blind folded(BF) control and sighted(S) control. All the participants were right handed.

The participants performed a proprioceptive localization task. The participants placed their right hand facing the palm side up inside of an occlusion box (40 X 40 X 8 cm) placed in front of them on a table. Ten landmarks on the hand (5 knuckles and 5 finger tips) were used as the target locations for the task. The participant had to point to their perceived location of the target using their non-occluded hand. The target location was verbally instructed by the experimenter in random order. Each participant did a total of 100 trials in 2 blocks of 50 trails each. The localization judgements were recorded using a camera (C290 HD) which was suspended above the box using a tripod. The locations estimated by the participants were used to generate implicit hand maps of the participant and extract necessary measures like finger length and hand width.

A blindness severity score was calculated for the blind participants using the Scale of functional Vision developed by (Douglas,G., Corcoran,C., & Pavey, S.,2006). This scale indicates the level of visual information that is perceived by the blind person, irrespective of color, cause of blindness and other factors.

Results:

We analyzed three measures from the data i.e. the finger lengths, hand width and the Napier’s shape Index. The magnitude of under estimation in the blind group was consistently lower across all of the fingers excluding the thumb.

We found the characteristic underestimation of finger lengths and over estimation of hand width across the three groups which has been shown in the previous studies. All three groups showed a significant underestimation of finger lengths; Blind [−33.76%, $t(29) = 12.245$, $P < 0.001$], sighted group [−22.86 %, $t(29) = 13.592$, $P < 0.001$] and blindfolded control groups [−19.27%, $t(29) = -8.45$ 7, $P < 0.001$]. All three groups show significant overestimation of their hand widths; Blind(B) [42.99 %, $t(29) =−3.5$, $p = 0.662$], sighted(S) [18.74 %, $t(29) = -0.224$, $p = 0.826$], and blindfolded(BF) [31.77 %, $t(29) = -0.224$, $p = 0.826$].

The blind group showed a larger overestimation of the hand width compared to both the groups [ $F(2) = 5.300$, $p = 0.007$, $\eta 2 = 0.077$], but was significantly higher only compared to the sighted group. The Napier’s shape index of Blind group was significantly larger than the other two groups [ $F(2) = 11.978$, $p < 001$, $\eta 2 = 0.216$] .

We correlated the blindness severity scores with our estimated hand measures (finger length, hand width, shape index). We found that the estimated hand width is significantly correlated with the severity of blindness (Pearson’s $r = 0.576$, $p < 0.001$). Participants with severe blindness showed lesser overestimation. Finger length estimation did not show any significant correlation with blindness severity. However, there was a strong negative trend, such that with increased blindness severity, there is a reduction in the under estimation of their finger lengths. The Napier’s shape Index showed a strong positive correlation (Pearson’s $r = 0.581$ and $p < 0.001$).

Discussion:

Our results indicate that the stereotypical distortions of the body model that are observed in the normally sighted population are also present in the blind. However, the blind group showed significantly larger distortions in comparison with

the control groups. The Blind group in our study showed significant overestimation of hand width when compared with the sighted group. The blind group also had the Napier's shape index significantly larger than the other two groups. We also found that the percentage overestimation of hand width and the Napier's shape index had a positive correlation with the severity of blindness whereas the estimated finger lengths showed a trend of negative correlation. Interestingly, the correlation trends between the measures (Finger lengths, Hand width, Shape Index) and the severity of blindness indicate that the higher the severity of blindness the lesser the magnitude of distortions, thereby showing that absence of vision in the congenitally blind led to development of a better body model compared to the blind participants with partial vision.

# Effect of External Spatial Limb Position on Tactile Enumeration

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INTRODUCTION

The external position of our body in space affects tactile perception. The spatial location of limbs has been shown to affect aspects such as stimulus localization (Millar & Al-Attar, 2004), stimulus-based limb identification (Riemer et al., 2010) and temporal order judgements (Shore et al., 2005). However, to our knowledge. the effects of external limb position have not been explored in tactile enumeration, Enumeration is the process by which we judge the total number of perceived stimuli (stimulus numerosity). This enumeration can occur in three ways: counting, estimation, and subitizing (Riggs et al, 2006). Counting is a serial process, where enumeration time increases linearly with numerosity, estimation is a fast, parallel and inaccurate process. And subitizing is a fast and accurate judgement only possible for a small range of numbers known as the subitizing range (Kaufman et al., 1949). In touch, this range is reported to be from 1-3. Subitizing has been characterized using bilinear and sigmoidal curves. (Leibovich-Raveh et al, 2018). In this study, we investigated how tactile enumeration is affected when hands are crossed across the body midline and when intertwined at the midline as compared to a normal posture. Furthermore, we also checked for the presence of subitization via curve fitting. We expected overall performance to decrease when limbs are not placed on their respective sides of the body midline.

METHODS

Participants (n = 15, two females, mean age = 19.93, SD = 1.95) sat with their hands palm side down on a table. Eight vibrators (8mm coin motors) were attached to their fingers, excluding thumbs. In a trial, a random number of motors activated simultaneously for 700ms (frequency: 250hz), preceded by a visual cue (500 ms) by 500 ms, a paradigm based on previous literature (Cohen et al, 2014). Participants were instructed to verbally report the number of stimuli they perceived as quickly and accurately as possible and responses were recorded using a microphone. Response Times (RT) and Response Error Rate (RER) were calculated. Participants performed the experiment in three conditions: Normal (hands placed at shoulder width), Cross-mid (hands crossed across body midline) and Intertwined (fingers intertwined, hands at body midline), with the Normal being our control. Participants kept their fingers separate and rested while intertwining them. The order of the conditions was counterbalanced, and each condition had 120 trials divided into two blocks with each numerosity being presented 15 times. Participants placed their hands on a soft towel, and breaks were given between blocks to prevent finger strain and discomfort.

RESULTS

We found that Response Error Rates (RER) and Response Times (RT) linearly increased with respect to numerosity, with the lowest values found for numerosity 1 and the highest values found for numerosity 7 (performance for numerosity 8 improves drastically since participants need not enumerate; the answer is fixed to be the maximum value possible). The Intertwined condition showed higher RER values as compared to Normal and Cross-mid. A two-way repeated measures ANOVA on the error rate (RER) was performed, taking numerosity and conditions as the within subject factors. Significant main effects of both Numerosity ($F(7, 359) = 166.187$, $p < 0.001$) and Condition ($F(2, 359) = 5.488$, $p = 0.008$) were observed but no interaction effects between Numerosity and Condition were observed ($p = 0.497$). To further investigate the effects of condition on numerosity perception, we performed one way RM-ANOVAs on RER for each numerosity and found significant effects of condition for all numerosities except for 5 and 7. Similar ANOVAs were performed on RT with no significant effects, possibly due to large variations arising due to the manual calculation of RT.

To test for subitizing, we performed linear curve fitting, and found high R2 values for Normal (RER R2 = 0.8906; RT R2 = 0.8201), Crossmid (RER R2 = 0.8817; RT R2 = 0.6701) and Intertwined condition (RER R2 = 0.8; RT R2 = 0.5725). Since the subitizing range is reported to be 3, we also performed linear fits within the subitizing range (Normal RER R2 = 0.9468, RT R2 = 0.96698; Crossmid RER R2 = 0.97996, RT R2 = 0.85387; Intertwined RER R2 = 0.93677, RT R2 = 0.94455). The high R2 values imply that only one process is occurring across the number range.

DISCUSSION

Our results show that external limb position affects tactile enumeration (significantly for numerosities 1-4 and 6, the remaining showing similar trends). A possible reason for these effects is that our brain uses two frames of references, the aforementioned external-dependent frame and an internal, somatotopic-based frame (Millar & Al-Attar, 2004) during tactile perception. The external frame usually aligns with our internal somatotopy because our limbs naturally occupy an external space on the same side of our body midline. Body positions in which limbs cross the midline break the synchrony between frames, resulting in increased errors. These positions have been named as Non-canonical positions. Lastly, since our data shows strong linear fits, we conclude that it shows a single linear process for enumeration, and that the presence of subitizing is unlikely. A similar conclusion was obtained by Gallace (Gallace et al, 2006).

## Wait Before You Leap : Influence of Instruction Sequence on Visual Search Task

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RITL or rapid instructed task learning is an ability which allows humans to efficiently perform actions following a set of novel instructions without prior practice. Yet, the impact of instructions on various tasks and the mechanism underlying the ability is not well understood. Specifically, there are very few studies addressing the impact of the nature of instruction and its sequencing in information processing by the brain and subsequent performance on a visual search task. In this study, we test the effect of specification of the target and the time course of instruction leading to the taks, on the efficiency of search tasks. In order to gain insights about this aspect of visual search tasks, we designed the target stimulus of this study in such a way that it could become either a feature search or conjunctive search based on instructions. Having shown the efficacy of this test set to show differences in the two types of instructions on identical stimulus sets, we manipulated the time course and method of instruction to test its effect on the search performance. We quantify the search performance over trials to see if the advantages that the practice over trials give, can be achieved by varying the mode of instruction alone.

Five different protocols using four different set sizes (i.e. 1, 2, 4, 6) were administered for a group of 15 people each. The protocols were different in terms of target stimulus specification and time allotted to the subject (Self-Paced, Imagine the target for 15 sec after instruction or a fixed duration instruction of 30 seconds) before the search trials started. The 'Fully Specify (Self-Paced)' instruction group was given a full description of the target stimulus i.e. 'The object here is a pattern which has a circle on the right hand side and the square on the left hand side', and this set of instructions were self-paced. For 'Fully Specify (30 Seconds)' instruction group, the same description of the target stimulus was used as in 'Fully specify (Self-Paced)' but the difference is that here the set of instructions was not self-paced and the participants have to stay on the specific instructions screen for about 30 seconds before the practice trial starts. For, 'Partially Specify (Self-Paced)', there was a partial description of the target stimulus i.e. The object here is a pattern which has a circle on the right hand side (or square on the left hand side) and this group was also self-paced. For the 'Picture (Self-Paced)' instruction group, we had a picture showing the target stimulus instead of textual description and participants had to press the SpaceBar in order to move to the practice trials. Finally, for 'Imagine the Target' we had a full description of what a target would look like and it was self paced but the specific instructions were followed by a time window of 15 seconds where the participants were asked to imagine what the target stimulus would look like before they start the task

On performing a 4*2 mixed group ANOVA, we found a significant effect of protocol on search performance (RTs across all sizes) with the 'Partially specify' (Self-Paced) group performing better than 'Fully specify' (Self-paced) [$F=10.43$; $p<0.002$]. Surprisingly, we also observed a statistically significant decrease in RT across set size for fixed time duration (30 Seconds) of instructions compared to self-paced [$F=10.13$; $p<0.002$]. This shows that there were significant improvements in task performance with changing instruction, and that improvement was solely because of the instruction as the task to be performed was the same for every instruction group. Also, we noted that the interaction effect was insignificant for all the group comparisons, meaning there was no significant difference between the slopes of various instruction groups.

In many experimental and real life tasks, the instructions given to the participants are self-paced, meaning they rely on the notion that when participants decide to move past the instructions they have developed an understanding of what they are supposed to do in the task. In this study, we show that enforcing an interval between the time at which the participant declares understanding of instruction and the start of the task improves the performance as measured by reaction time in a visual search task. This suggests that the awareness of the understanding of instructions as seen in the case of a self-paced instruction task is not enough for optimal performance and points to unaware ongoing processes of the brain configuration in order to convert the declarative representation of the task effective for execution. (Marcel Brass et. al., 2017).

As a result, we concluded that the way target stimulus is defined have a severe impact on search performance during visual search task, also comprehension of target stimulus specification and instruction is necessary but not a sufficient prerequisite of optimal performance and finally task preparedness effect search performance in a way which is beyond our understanding with current literature and needs further investigation.

**Altered cortical effective connectivity is a signature of chronic pain perception and placebo response**

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RITL or rapid instructed task learning is an ability which allows humans to efficiently perform actions following a set of novel instructions without prior practice. Yet, the impact of instructions on various tasks and the mechanism underlying the ability is not well understood. Specifically, there are very few studies addressing the impact of the nature of instruction and its sequencing in information processing by the brain and subsequent performance on a visual search task. In this study, we test the effect of specification of the target and the time course of instruction leading to the taks, on the efficiency of search tasks. In order to gain insights about this aspect of visual search tasks, we designed the target stimulus of this study in such a way that it could become either a feature search or conjunctive search based on instructions. Having shown the efficacy of this test set to show differences in the two types of instructions on identical stimulus sets, we manipulated the time course and method of instruction to test its effect on the search performance. We quantify the search performance over trials to see if the advantages that the practice over trials give, can be achieved by varying the mode of instruction alone.

Five different protocols using four different set sizes (i.e. 1, 2, 4, 6) were administered for a group of 15 people each. The protocols were different in terms of target stimulus specification and time allotted to the subject (Self-Paced, Imagine the target for 15 sec after instruction or a fixed duration instruction of 30 seconds) before the search trials started. The 'Fully Specify (Self-Paced)' instruction group was given a full description of the target stimulus i.e. 'The object here is a pattern which has a circle on the right hand side and the square on the left hand side', and this set of instructions were self-paced. For 'Fully Specify (30 Seconds)' instruction group, the same description of the target stimulus was used as in 'Fully specify (Self-Paced)' but the difference is that here the set of instructions was not self-paced and the participants have to stay on the specific instructions screen for about 30 seconds before the practice trial starts. For, 'Partially Specify (Self-Paced)', there was a partial description of the target stimulus i.e. The object here is a pattern which has a circle on the right hand side (or square on the left hand side) and this group was also self-paced. For the 'Picture (Self-Paced)' instruction group, we had a picture showing the target stimulus instead of textual description and participants had to press the SpaceBar in order to move to the practice trials. Finally, for 'Imagine the Target' we had a full description of what a target would look like and it was self paced but the specific instructions were followed by a time window of 15 seconds where the participants were asked to imagine what the target stimulus would look like before they start the task

On performing a 4*2 mixed group ANOVA, we found a significant effect of protocol on search performance (RTs across all sizes) with the 'Partially specify' (Self-Paced) group performing better than 'Fully specify' (Self-paced) [$F=10.43$; $p<0.002$]. Surprisingly, we also observed a statistically significant decrease in RT across set size for fixed time duration (30 Seconds) of instructions compared to self-paced [$F=10.13$; $p<0.002$]. This shows that there were significant improvements in task performance with changing instruction, and that improvement was solely because of the instruction as the task to be performed was the same for every instruction group. Also, we noted that the interaction effect was insignificant for all the group comparisons, meaning there was no significant difference between the slopes of various instruction groups.

In many experimental and real life tasks, the instructions given to the participants are self-paced, meaning they rely on the notion that when participants decide to move past the instructions they have developed an understanding of what they are supposed to do in the task. In this study, we show that enforcing an interval between the time at which the participant declares understanding of instruction and the start of the task improves the performance as measured by reaction time in a visual search task. This suggests that the awareness of the understanding of instructions as seen in the case of a self-paced instruction task is not enough for optimal performance and points to unaware ongoing processes of the brain configuration in order to convert the declarative representation of the task effective for execution. (Marcel Brass et. al., 2017).

As a result, we concluded that the way target stimulus is defined have a severe impact on search performance during visual search task, also comprehension of target stimulus specification and instruction is necessary but not a sufficient prerequisite of optimal performance and finally task preparedness effect search performance in a way which is beyond our understanding with current literature and needs further investigation.

**Temporal integration influenced by the nature of temporal context**

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Perception in real-time constitutes an active construction of content. To understand the ongoing mechanism of how perceptual content is organised in time, temporal windows of processing are often called upon. Integration of information within temporal windows offers a way to explain how we perceive time-extended phenomena like motion, succession, melody etc. Is temporal integration within such windows isolated to time frames containing that information or is it dynamically influenced by the just-preceding and just-succeeding temporal context?

To study this, we had developed a novel paradigm of temporal integration where two halves of a Kanizsa square are integrated together (seeing a full square) or segregated (not seeing a full square) as a function of temporal gap between them. The inter-stimulus interval (ISI) between the two halves was varied across 10, 30, 50, 100, 300, 500, 1000ms. The two halves (T1 & T2) are preceded and succeeded by rotating discs of the same Kanizsa square either in a temporally a) correlated (predictable) or b) random fashion. That is, in any trial, the discs keeps rotating in (a) or (b) fashion and they culminate into and out of the orientation in T1 and T2 before and after their presentation, respectively. We asked participants (N=26) to report whether they perceived a full square or not within the sequence. In the current study, the rotation increments of the discs, in both conditions, are randomly sampled from truncated normal distribution with an absolute mean of 30 deg and a standard deviation of 20 deg. This was done to control for mean rotation-angle increment differences in both conditions. Across 224 trials, we calculated the proportion of square seen by the participant across the seven ISI and two temporal context (correlated, random) conditions. In line with results from our first experiment (where we didn't control for angle increment differences), there is a significant main effect of 1) ISI where the average proportion of trials in which participant's reported seeing a square decreased with increasing ISI and a main effect of 2) temporal context where the average proportion of trials in which square was seen was significantly higher for correlated condition compared to the random condition (Fig. 1). Even though we expected an interaction between ISI and temporal context, it was not significant. Since there are no right or wrong responses in this task technically (given T1 & T2 were present in all the trials with a variable gap), we couldn't perform the SDT analysis. We are going to explore the possible differences in criteria and sensitivity in the ongoing follow-up experiment. Our study shows that integration of perceptual information extends temporally beyond the frames containing that information, and is systematically influenced by the nature of the preceding and succeeding temporal context. Surprisingly, people were able to see the square in 50% of the trials even when the ISI was 1 second. One possibility could be the sufficiency of seeing one half to elicit a perception of the square. We are exploring this possibility by having conditions where the halves are not present in all trials as part of the ongoing follow-up. This effect needs further validation to see whether integration can occur over such a long interval under certain conditions. Future studies would be needed to study the extent of this influence.

# The influence of cueing-time, and attentional breadth on sensitivity and awareness in change detection; evidence in support of the limited capacity view

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Introduction

Attention has been shown to influence awareness using multiple paradigms. Our ability to perceive has also been shown to be limited in certain circumstances. For example, people are not very good at detecting changes in their visual environment, which is called change blindness presumably due to the fleeting nature of representations and limited capacity to detect changes (Simons, 2000). On the other hand, some have argued for large capacity to detect changes (Landman et al., 2003). Recently, this has been addressed in recent studies by varying the timing of the spatial cue in spatial array tasks (Chiarella et al., 2023; Simone et al., 2019).

Given our perception is mostly for real-world scenes, as well as the fact that spatial attention can vary in terms of its scope not just cueing-time, the current study manipulated cue-presentation time as well as the scope of attention in a spatial cueing task, and measured participants' sensitivity as well as awareness. Two cues with variable sizes were presented to manipulate the scope of attention by presenting them either during the initial scene (pre-cue), between the two scenes (ISI-cue) and the second scene (post-cue). Earlier, we had shown that cue size and cue timing influence change detection performance. Here, we study the effect of cue size and cue timing on awareness using an awareness scale.

We hypothesized that not just performance, but awareness rating would be influenced by cue size and cue timing. We expected in general that the performance as well as subjective awareness would reduce for the larger cued region compared to the smaller cued region, especially for the ISI and post cues. More specifically, for subjective awareness ratings, we hypothesized higher ratings for small compared to large cue as well as for pre-cue compared to the other two cues. We also expected higher ratings for the change compared to the no-change condition.

Methods

Twenty-four participants (mean age = 25.16 years) participated in this study. The sample size was estimated with a medium size effect size of Cohen's f = 0.5 for the interaction between cue-size and cue-timing, alpha = 0.05, and power = 0.90. The study was approved by the ethics committee. The design was a 2 (cue-size: small, big) by 3 (cue-timing: pre-cue, ISI-cue, post-cue) repeated-measures design. The stimuli were 156 images of natural scenes consisting of landscapes or buildings, presented on a 24-inch monitor. Half of these images contained changes while another half did not contain any change. The size of the scenes was kept 17.13×13.33 centimetres. All the cues were squared shaped with 2 different sizes (small, big) (figure 1). The overall experiment was designed in PsychoPy. The perceptual awareness scale (PAS) was used to measure participants' awareness of change or no-change on a 4-point scale varying from no experience at all to fully clear. The trial structure for each trial was: Fixation (2000 ms) → Scene 1 (1000 ms) → Blank interval (2000 ms) → Scene 2 (1000 ms) (figure 2). In figure 2, the white-colored empty rectangles represent the presentation time of the cue on the screen. For example, in the pre-cue condition shown in figure 2, scene 1 was presented for 1000 ms while the cue appeared during the midway of this presentation (after 450 ms) for 100 ms. Similarly, for the ISI-cue condition, cue appeared for 100 ms in the middle of the blank interval screen. Similarly, for the post-cue condition, cue appeared for 100 ms after during the middle of the presentation of the scene 2. All the changes in the stimulus happened only in scene 2. In total, there were 156 trials, with half the trials containing a change and the other half containing no-change. The presentation of cue-types (both size and timing), as well as change-condition (change, no-change) were fully randomized. Counterbalancing was done within each of change and no-change conditions done so that no image appeared more than once in any condition, to any participant.

Results

Objective performance analysis:

Signal detection theoretic measures (d′) were calculated using R software's psycho library. A 2-way repeated measures ANOVA was performed ond′ (see figure 3) with cue-timing (pre-cue, ISI-cue, post-cue) and cue-size (small, big) as within-subject variables. All post-hoc comparisons were Bonferroni corrected. The main effect of cue-size was significant $F(1, 23) = 13.15$, $p < .001$, $\eta p2 = .364$. Performance with smaller cue size (1.07) was better than with the larger size cue (0.76). The effect of cue-timing was also significant, $F(2, 46) = 51.76$, $p < .001$, $\eta p2 = .692$. Performance was better for the pre-cue (1.61) compared to the other cues. ISI-cue and post-cue performance was not significantly different from each other. The interaction between cue-size and cue-timing was significant, $F(2, 46) = 7.80$, $p < .001$, $\eta p2 = .253$. Post-hoc comparisons showed better performance in the small compared to the big cue condition only for pre-cue.

Subjective awareness analysis:

A three-way RM ANOVA with change, cue-timing, and cue-size as variables on the subjective ratings was conducted (see figure 4). There was a main effect of change, $F(1, 23) = 4.39$, $p = .04$, $\eta p2 = .160$, and cue-timing $F(2, 46) = 78.85$, $p < .001$, $\eta p2 = .774$. The main effect of cue-size was not significant. The ratings were higher when there was a change

compared to when there was no change. Participants reported significantly more awareness rating for the pre-cue compared to ISI-cue and post-cue conditions. There was a significant interaction between cue-timing and cue-size, $F(2, 46) = 3.25$, $p < .05$, $\eta p2 = .124$. The effect of size (ratings larger for small) was present for pre-cue. There was also an interaction between change and cue-timing $F(2, 46) = 3.46$, $p < .001$, $\eta p2 = .137$. Participants showed significantly higher awareness for change compared to no change in the pre-cue and ISI-cue conditions, but not in post-cue condition.

Discussion

The results indicate that the capacity to detect changes is not large and is limited as evidenced by the significantly less performance and awareness rating for the ISI-cue and post-cue conditions. Attentional breadth does matter but influences performance only when the cue was provided ahead of change. Interestingly, the effect of size on awareness ratings is present for both the pre-cue and ISI-cue conditions. There is a trend for ISI-cue indicating that the rating is more for big cue compared to the small cue. The results indicate that attentional scope influences visual appearance in terms of awareness. Our capacity to consciously perceive changes is limited due to limitations in attention and visual short-term memory.

## Does Temporal Attention Dilate the Perceived Duration?

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Introduction

Spatial attention influences visual perception by enhancing visual resolution at the attended location (Solomon, 2004). Similar effects have been found for temporal attention, a phenomenon where we can direct our attention to a specific point in time (Griffin, Miniussi, & Nobre, 2001). Temporal attention leads to prioritization of information at a specific time, which has been found to improve performance in a visual task (Griffin, Miniussi, & Nobre, 2001). Studies on the effect of temporal orienting have found that when the cue is valid, with a shorter RT. For example, Coull and Nobre (1998) also found that RTs were significantly faster when valid informative cues were provided than when neutral or invalid cues were used. However, only a few studies have attempted to study how temporal orientation affects time perception. Correa et al. (2006) presented temporal cues (early v/s late) and asked participants to report which of the two LED lights presented in two spatial locations appeared first. They found the effect of cue validity with a higher temporal resolution for valid cues, suggesting that temporal orienting had enhanced temporal resolution. Enhanced spatial resolution at the cued time point is often linked to temporal attention. An alternative explanation suggests that perceived stimulus events expand at the cued time, aiding spatial information processing. Without temporal attention, events are subjectively experienced as shorter, leading to less effective spatial processing. In the current study, we aimed to test this hypothesis by manipulating temporal attention (early or late) with valid and invalid visual cues in a temporal bisection task. We expect temporal dilation for the valid temporal cue trials compared to invalid ones.

Method

Participants:

All the participants were students of the University of Allahabad with an age range of 18-25 years. The study is ongoing, and we have collected data from 12 subjects (n=12). Data for 23 more subjects will be collected (Total N=35 based on sample size calculation).

Task: We used a temporal bisection task with short and long anchor durations of 200 and 800ms. In the task, a cue was presented, which informed the participants when the stimulus would appear. A green circle indicated that there would be a short delay (250ms), and a red circle indicated that there would be a long delay (750ms). The cue was valid in 50% of trials and invalid in 50%. The visual stimulus used for the bisection task was a blue square of 324*324 pixels. Each trial started with a fixation cross of 800ms followed by a temporal cue in the form of a (green/red) circle for 300ms centrally on the screen. The target stimulus was presented for one of the seven stimulus durations ranging from 200ms to 800ms in a step size of 100, and the participants gave short or long responses by pressing pre-specified keys on the keyboard. There were a total of 28 conditions (7 stimulus target presentations with 2 CTOAs, which were either valid or invalid) with 10 trials in each, leading to 280 trials.

Results:

We conducted a 2 (Early vs. Late) x 2 (Valid vs. Invalid cue) x 7 (Test Duration) repeated-measures ANOVA on the proportion of long [p(long)] responses. There was a significant effect of cue validity with $F(1, 11) = 5.73$, $p = 0.036$. Additionally, we used a Sigmoidal Logistic function, type 1, to plot the proportion of long [p(long)] response data (N=12) that was calculated for each of the 7 test durations for each of the four different conditions. A 2 (Early v/s Late) x 2 (Valid vs. Invalid cue) repeated measures were conducted on the PSE and JND of individuals. The results did not reveal any significant difference in time delay (short vs long) of both PSE with $F(1, 11) = 0.326$, $p = 0.579$ and with JND $F(1, 11) = 0.115$, $p = 0.741$. Additionally, there was a trend for the effect of validity of cues (valid vs. invalid) in both PSE with $F(1, 11) = 3.411$, $p = 0.092$, and JND with $F(1, 11) = 2.234$, $p = 0.163$. Generally, the PSE for the valid cue condition was shorter than the invalid cue condition. However, the study is ongoing, with data showing trends towards our hypothesis.

Discussion:

This is an ongoing study, and the data collection is going on. However, the data (N=12) presented here clearly shows a trend for the effect of cue validity, indicating that cueing the temporal attention is likely causing time dilation. The results have important implications for our understanding of the role of attention in time perception. Previous studies have suggested that the stimulus that engages more attention, e.g., an oddball stimulus, leads to a longer perceived duration of the oddball stimulus compared to a standard stimulus of the same duration (Tse et al., 2004). These results have been used to argue that attention to a visual stimulus results in more information being processed and, hence, more ticks being accumulated in the framework of the attentional gate model (Li, Yu & Yuen, 2022). One of the critical findings of our study is that cueing participants to attend to specific time points can affect their perception of duration, suggesting that our cognitive processes, such as attentional allocation, can modulate how we perceive time.

**Theoretical and Computational Modelling of Visual Perception using hybrid techniques like DCNN, Reinforcement Learning, and Recurrent Neural Networks in opening new dimensions in understanding the perceptual organization and Cognitive architectures of the brain which can be used as a tool in the development of Artificial General Intelligence**

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As of today, we do have certain computational models that deal with the recognition-based learning approaches these types of recognition-based models are broadly serving their application in the field of artificial intelligence But, all of these come under the narrow AI. As far the the Artificial General Intelligence is concerned the dimensions to explore this are limited due to the limited understanding of the Cognitive organization in the brain and the set of cognitive processes it can incorporate. In this research, We are focusing on the Limited understanding of this cognitive organization of mind. For this cognitive organization, we have classified various cognitive processes like learning, perception, attention, and memory. Still, there is a huge gap for said to be a functional cognitive organization of the brain which can mimic the mind and provide the deeper dimensions for exploring the possible models of cognitive architectures.

Here we are trying to formulate a theoretical model in which the flow of the organizations takes three levels of processing: first is the level of the visual sensory information(data), second is the processing of this visual sensory data and comprehending it to a mental representation of multiple data arrays and using a combination of Hybrid computational modeling using DCNN, Reinforcement and at last the RNN based sub-processing to formulate a robust visual perception model which is providing ways to describe the underlying sub-process in visual perception in the brain, here sequence feature detection, visual attention, perceptual grouping, visual memory, object recognition, visual adaptations, integration among these sub-processes. The exact path and flow of data is formulated and then the hybrid approach of incorporating the various technologies mentioned is used to test these. We are using the COCO and ImageNet datasets for storing the visual information in our models and then training it on UCF-101 to make it workable in the common setting. A spatial recognition task is also performed at the end to bind up this hybrid model.

We found out this sort of hybrid setting can provide some accuracy in explaining visual perception as a step-by-step tool verifying it computationally and leading to opening the broader dimension to decode the human visual perception in making cognitive organization inside the brain these results are now said to be basis of a hybrid cognitive architecture.

## Enhanced Working Memory Performance Linked to Prefrontal Global Network Measures: An fNIRS Investigation

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Introduction
Working Memory (WM) is an important domain of cognition that enables an individual to acquire, retrieve and implement recent memory for various tasks. N-back is one of the most widely examined tasks for studying WM in patients with neuropsychiatric disorders as well as healthy subjects. Functional organization of the prefrontal cortex may determine the working memory capacity of the individuals. Functional near infrared spectroscopy (fNIRS) is a neuroimaging tool based on the principle of spectroscopic acquisition and study of hemodynamics. It is a novel, portable, easy to administer, and relatively cost-effective with a higher temporal resolution acquisition tool as compared to functional Magnetic Resonance Imaging (fMRI). Functional organization of the brain can be assessed reliably during the resting state (rs) using fNIRS. This study aims to understand the association of prefrontal network organization and working memory performance in healthy individuals through fNIRS.

Methods
After screening the subjects to rule out psychiatric disorders using MINI Plus 7.0.2, for the selection of healthy controls. Handedness of the Healthy controls was assessed using Edinburgh Handedness Inventory and Twenty-five healthy subjects (age:25.52±3.89years, 18 Males & 7 Females) after performing underwent 10-minute rs-fNIRS and N-Back (zero-, one- & two-back) task. Concentrations of oxyhaemoglobin (HBO) and de-oxyhaemoglobin (HBR) were computed from 8*8 optodes positioned over Bilateral Prefrontal Cortex (PFC). Performance accuracy D' (d prime values) using signal detection theory was calculated alongside mean reaction times. Graph theory global network measures of Assortativity, Hierarchy, Global and local efficiency, small worldness and synchronization were computed for each subject after standard preprocessing of the Oxygenated and deoxygenated signals obtained from fNIRS recording using GRETNA. Network sparsity model was applied using correlation thresholds from 0.05 to 0.95, with increments of 0.05 and area under the curve was calculated on the data obtained through fNIRS, for all the global network measures. Pearson's correlation, after testing for normality, (Shapiro-wilk Value = 0.939, p=0.141) was done to find correlation between network AUC measures and n-back measures. Considering multiple hypothesis testing Bonferroni corrected alpha value (p=0.005) was considered as cut-off for a statistically significant correlation.

Results
Two Back performance accuracy had a significant positive correlation with area under the curve (AUC) of global efficiency (Eg) (r=0.617, p=0.002) and negative correlation with that of shortest path length (Lp) (r=0.617, p=0.002) as measured using HbO signals. Also, Eg had a significant positive correlation with zero back accuracy (d') (r=0.575, p=0.004). Additionally, there was a strong positive correlation in HBR derived Local efficiency (Eloc) with Zero-back Reaction time (r=0.647, p=0.001).

Conclusion
The greater accuracy in working memory task correlated with greater prefrontal cortex global and local efficiency and small worldness suggesting that better bilateral dorsolateral prefrontal cortex(dlPFC) intra connectivity is likely to enhance N-back performance. The findings suggests that a well-connected bilateral dlPFC would support the executive functioning. The research reveals that short duration resting state fNIRS would provide important clues regarding the neurobiological underpinnings of the WM. This can be easily acquired in clinical settings and may have clinical utility in understanding the pathophysiology behind neurocognitive deficits. Subsequent research with larger and more diverse sample focusing on clinical population can provide further insights into the same topic.

## Seeing Yourself in Others: The Effect of Self Similarity on Memorability of Faces

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Introduction

Among the many faces we encounter every day, some are remembered while others are easily forgotten. Memorability refers to the likelihood of a stimulus being retained in memory enough to be remembered later. Memorability for certain faces has shown to be consistent across participants where they tend to remember and forget the same faces (Bainbridge, 2016); and is dependent on many factors like familiarity, trustworthiness, atypicality, faces of your own age/race/gender.

This study attempts to search for a higher order factor which drives memorability. Considering how previous studies have shown the same-age effect, the same-race effect, along with perceived trust and familiarity to individuals as factors contributing to face memorability we speculated that self-similarity could be the meta-factor that drives memorability. Typically, things encoded in reference to oneself are remembered better, known as the self-reference effect. Faces perceived to be similar to oneself are also perceived to be more trustworthy. This study investigates if perceived self-similarity underlays all these factors in relation to the self-reference effect.

Methods

Participants: Fifty-one people participated in this study, out of which there were 34 females, 16 males and 1 non- binary participant with the mean age of 21.8. Materials:The Experiment used the Chicago Face Database - India consisting of 142 unique individuals. The dataset included extensive norming data of each individual model with objective (e.g., facial dimensions, pupil size, etc.) as well as subjective ratings by independent judges (e.g., attractiveness, trustworthiness, threatening, etc.) Procedure:Participants performed a continuous recognition task, observing a stream of 190 images and responding when a previously seen face reappeared (designated by pressing 'r'). Each image was displayed for 1 second, separated by a 1.2-second interval (Fig. 1). Among these, 30 were designated as “target" images, with the remaining 112 serving as “filler” images. In the initial experiment, target images were randomly inserted at various points, followed by their repetition after 23 intervening images. As an attention check, 18 of the filler images were presented as “vigilance” repeats, placed 1-7 images apart. Data was excluded if participants scored below 25% on hit rate or above 50% on false alarms for vigilance repeats, indicating inattentiveness. The second part of the study followed a rating of the target faces on the basis of how similar the face looks to you (the participant), and a friend using a 5-point Likert scale from 1 (not similar at all) to 5 (very similar).

Results

The memorability score for each target image was calculated as its hit rate (HR), while fillers or non-repeating images were analysed through their false alarm rate (FA). Logistic regression was used to analyze the relationship between self-similarity and hit rate. It was found that, holding all other predictor variables constant, the odds of a correct response occurring only increased by OR = 1.626 with an estimate of 0.486 (95% CI [-2.289, 3.262]) for a one-unit when self-similarity was 5. After accounting for age and gender (implicit similarity), there was a close to significant correlation found between self-similarity and hit rate $t(29) = 1.895$, $p = 0.069$. A linear regression was also performed to see if there was a significant relationship between friend similarity and hit rate, and the result was not significant $t(29) = 0.214$, $p = 0.832$ (Fig. 2) A significant negative correlation was found between absolute deviation of age (participant versus target age) and hit rate, $r(2) = -0.598$, $p = 0.014$ such that the hit rate was highest when participants saw faces of their own age. It was also seen that the own-gender effect was asymmetrical: females found female faces to be more memorable, however males did not show an own-gender bias. Subsequently, when self-similarity ratings and hit rate where correlated with standardized social attributes, self-similarity ratings found significant correlations in line with hypothesized social attributes (Fig. 3 & 4).

Discussion

Enhanced memorability of faces aligns with greater self-similarity in age, gender, and race. This self-similarity corresponds to favorable social qualities. The results mirror past research associating self-similar faces with trustworthiness, warmth, and attractiveness. This resemblance also caters to familiarity effects, reinforcing prior age-related and female self-gender bias findings (Anastasi & Rhodes, 2005; Herlitz & Lovén, 2013). The own-gender bias could stem from using one’s own gender face as a reference point for comparison, benefiting from familiarity. For instance, females may concentrate on diagnostic female features like eyes and mouth (Lovén et al., 2011). All significantly correlated attributes with self-similarity exhibited a positive self-view bias. This outcome reflects a “self-other bias,” wherein positive qualities are deemed more self-descriptive, while contrasting for others. This mechanism explains the lesser self-similarity rating for threatening or angry expressions. Additionally, the tendency for participants to perceive more attractive faces as resembling themselves stems from the self-enhancement effect—enhanced self-perception of physical appearance. However, attractive faces did not impact memorability, aligning with previous findings linking symmetry to averageness and thus, reduced distinctiveness (Light et al., 1981). Even though the present study found some significant effects, ratings for self-similarity were skewed to the left with relatively fewer cases of rating 5, limiting the generalizability of the findings, except for implicit self-similarity results. The bias can be attributed to a “false-uniqueness effect,” where the self is perceived as unique to maintain a positive self-image and individuality (Suls, Jerry, & Wan, 1987). Future studies can use a 10-point scale to mitigate this effect for more varied responses.

Our analysis has revealed a significant relationship between recognition accuracy and temporal context. This relationship has been effectively visualized using a heatmap, which displays the expected accuracy levels across various durations and intervals (Fig. 5). We discuss the patterns in this heatmap further in the Discussion.

Discussion

The study demonstrates that temporal context is retrieved when image A is successfully recognized as having occurred before. This is because a subsequent image B is more accurately recognized if that image was part of the temporal context of image A, indicated by the negative coefficient of temporal context, implying a decrease in predicted accuracy with an increase in temporal distance. From the data analysis emerges a clear pattern: when self-distance remains constant, recognition accuracy gradually declines with increasing temporal distance between events (seen by looking at each row of Fig. 5 where the color gradients indicate decreasing accuracy with increasing temp_distance with self-distance being held constant). The decreased accuracy with increasing temporal distance is consistent with the predictions of the Temporal Context Model, which proposes that temporal context is a recency-weighted average of ongoing experiences and that this temporal context is retrieved when you remember the individual items later. In ongoing work, we are analyzing the fMRI data to determine the brain regions involved in representing and retrieving temporal context.

## Variant of nBack and SART tasks - a pilot vaidation study

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Background: Despite India's history of 40 years of neuropsychology [1], cognitive testing is still in its infancy. India's linguistic diversity restricts the development of normative data even for widely accepted digital cognitive tests like the n-back or sustained attention to response task (SART), used for assessing working memory and continuous task performance, respectively. Majority of the cognitive tests, like n-back, are designed for the English-speaking population and challenge the test administration with a population not well-versed in the English language.

Objective: This study seeks to address the above mentioned issue by developing language-independent variation of the n-back and SART tasks by replacing the alphanumeric characters with the images of everyday objects, such as "bag," "fan," and "bottle" as stimuli. This modification aims to make these cognitive tasks accessible to a linguistically diverse population, especially individuals with low literacy or illiteracy. Notably, most previous studies have primarily involved educated young adults, making our work distinctive in its inclusion of the economically and educationally diverse Indian population. This study is a pivotal component of a comprehensive project dedicated to developing a language-independent neuropsychological test battery for assessing fundamental cognitive functions, including working memory and sustained attention. Therefore, our primary focus is on innovating standard cognitive tests like the n-back and SART to facilitate an equitable evaluation of these cognitive functions.

Method: A total of 60 participants were recruited for the n-back (age: Median = 22, IQR = 11) and SART (age: Median = 22, IQR = 10) tasks, with 30 individuals for each task.. Further, 30 participants in each test comprised college-going students (n=20) with a minimum Bachelor's degree either pursuing or completed, and the housekeeping staff (n=10) with a wide spectrum of educational qualifications, ranging from primary level education to post-graduation. The latter group included individuals with limited proficiency in English language, primarily readers or speakers of Telugu or Hindi, but tested familiarity with basic reading of English letters and digits.
To create a language-independent version of the tasks, we conducted a stimuli familiarity study. Participants were presented with a comprehensive list (n = 32) of objects from categories: nature, kitchen, furniture, electronics and everyday-use items, and asked to rate their familiarity on a scale of 1 (least familiar) to 5 (most familiar). The top 10 objects with the highest familiarity ratings across all participants were selected for use in the modified tasks. Participants completed two sets of tasks: one using the original version (with English alphabets for n-back and digits for SART), and another with a new version replacing letters and digits with images of common daily objects.
N-back task: Both versions included 0, 1, 2 and 3-back tasks, each with 50 trials divided into two blocks. In both versions, stimuli were presented for 2000 milliseconds and the participant was supposed to press the button as soon as they identified the target.
SART task: Both versions of the SART task consisted of a total of 225 trials, comprising 200 GO trials and 25 NO-GO trials, distributed across five blocks to minimize participant fatigue. As the stimulus changed from digits to objects, stimulus duration varied between 250 milliseconds and 450 milliseconds. The chosen duration was determined through a participant comfort test and was consistent across both versions.

Results: We employed the Mann-Whitney test to compare participants' cognitive performance across the two task versions. Due to the lack of significant differences between the two task versions, we failed to reject the null hypothesis (Table 1). Students exhibited similar performance in both the original and the modified versions of n-back and SART tasks (Table 2). Similarly, housekeeping staff also demonstrated no significant differences in performance between the two versions (Table 3). A comparative analysis between the two participant cohorts showed a better performance by the students than the housekeeping staff for the two task versions. This observation illustrates the consistent pattern observed across both task versions. Spearman's correlation analysis was used to measure the relationship between the original and modified versions for both tasks (Table 4). The results showed a positive correlation between the original and modified versions of the N-back task, as well as the SART task.

Conclusion: The results suggest that regardless of literacy or socio-economic status, the new task version yields results akin to the original, exhibiting its suitability. The research is currently ongoing and offers the potential for a more comprehensive analysis, including the incorporation of Bayes factors. The inclusion of everyday objects as stimuli has an advantage over other language-dependent stimuli since the participants can perceive the displayed object in their preferred language and prepare their responses accordingly.Thus the shift from letters and digits to highly familiar objects paves the way for enhanced accessibility of these tasks to a wider audience. No difference in the traditional and modified versions of n-back and SART also supports the adaptation of these tests for more inclusive cognitive assessments.

**Unveiling Test-Dependent Discrepancies in Memorability Experiments: A Comparative Analysis**

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Introduction

In the realm of cognitive science, the phenomenon of memorability has garnered extensive attention due to its profound implications for understanding human memory processes. The capacity to encode, retain, and subsequently retrieve information is a central cognitive function that underpins many aspects of human cognition and behaviour. Whether in the context of educational instruction, persuasive advertising, or user interface design, the effectiveness of conveying information relies inherently on the extent to which it is memorable. Understanding the factors that influence the memorability of information is not only a theoretical pursuit but also has tangible practical applications.

While it has been theorized that memorability is intrinsic to a stimulus, it is not clear whether the different ways in which memorability is assessed influence the results. We explicitly compare the memorability scores obtained for the same stimuli using different memory assessment methods. We demonstrate that memorability patterns for the same stimuli are more consistent when assessed using the same type of memory test than when assessed using different methods, implying that theories about word memorability need to take into account the contexts within which the words are assessed.

Methods

Memorability, as a construct, refers to the inherent quality or characteristic of information, experiences, or stimuli that makes them more likely to be retained in an individual's memory over time. It encompasses various factors like salience, novelty, emotional impact, and personal relevance that influence how effectively something is remembered, as shown by Madan [Mad21]. The primary aim of this study is to investigate the role of experimental context in influencing memorability outcomes. We hypothesize that while memorability is frequently regarded as a holistic concept, it is significantly swayed by the idiosyncrasies of the experimental context. To test this hypothesis, we used data from multiple open sources and found out the free recall and recognition memorability scores.

Free recall experiment: For this experiment, the participants are shown a series of words for a fixed duration (1600ms/word in the case of PEERS), followed by a distractor task which consists of some simple mathematics problem, after which they are asked to recall as many words as they can remember from the shown list of words. This type of experiment may be more effective for measuring the overall strength of memory for a particular word, as it requires participants to rely solely on their own ability to recall information.

Recognition experiment: Recognition experiments involve presenting participants with a list of words, and then asking them to identify whether the word was a part of the original list of words or not. This type of experiment can be useful for measuring the degree to which a word stands out in memory relative to other similar words, as well as how well participants can discriminate between different words.

Firstly, we leveraged the PEERS dataset from Kahana et al. [Kah+22], a repository of cognitive experiments conducted across diverse populations. Secondly, we turned to the work by [Mad21] on word memorability, which presents an analysis of lexical properties and their influence on memory recall, which was also performed on the PEERS dataset. We use the Madan dataset to compare our computations against because we only use the first presentation of a word to account for a confound due to multiple presentations of a word across sessions within participants. Lastly, the Cortese dataset from Cortese, McCarty, and Schock [CMS15], another resource, augmented our analysis by contributing to recognition-based experiments.

Across the datasets above, we have data from both free recall and recognition memory tests. In the free recall datasets, we consider only the first exposure to the word for any given participant and compute the recall probability across participants to obtain the memorability score for a word. In the recognition data, we considered only the target words and similarly computed the recognition probability across participants to obtain the memorability score of a word.

Then, to assess the consistency of memorability patterns within and across memory tasks, we perform a shuffling procedure to test for significant correlations. Specifically, we first compute the Spearman correlation between the memorability scores obtained from two different datasets for a standard set of words. We then shuffle the word order in one dataset, recompute the Spearman correlation and repeat this procedure 1000 times to obtain a null distribution of correlations. The original correlation was deemed statistically significant if it exceeded 95%ile of the null distribution. This approach allowed us to establish the reliability and consistency of the correlation between the memorability scores.

Results

We use the following keywords to refer to the memorability scores from different datasets and memory tests:

- Ours-PEERS-recall - This is our computation of memorability scores from the free recall data in the PEERS dataset.
- Ours-PEERS-recog - This is our computation of memorability scores from the recognition data in the PEERS dataset.

- Madan-recall - This is Madan (2021)'s calculation of memorability scores from the recall data in the PEERS dataset. This computation likely did not consider the multiple times a given word was presented across experimental sessions within participants.
- Cortese-recog - This is our computation of memorability scores from the recognition data in the Cortese dataset.

In Figure 2, we present the correlation between the memorability patterns obtained from different datasets and memory tests. Notably, the correlation between the two recall experiments exhibits a high degree of similarity, indicating a robust alignment in their outcomes (see Figure 3) for the non-parametric statistical test showing that this is a statistically significant correlation). Similarly, the two recognition experiments also demonstrate a strong positive correlation (see Figure 4 for the non-parametric statistical test). However, across different experimental paradigms, we observe a strikingly low correlation, suggesting that the memorability scores are highly dependent on the specific test employed (see Figures 3-8 for the non-parametric statistical test showing that this correlation is not different from what one would expect by chance).

Cortese-recog.

Figures 5, 6, and 8 show the results of the non-parametric statistical tests comparing memorability patterns across different types of memory tests from the remaining combinations of datasets. While these correlations are small, they pass the 95th %ile threshold. However, it is clear that the correlations within memory tests are much higher and lie well outside the null distributions. Therefore, these analyses demonstrate that word memorability is influenced by the type of memory test used.

In this study, we have delved into the influence of experimental context on word memorability. Through an analysis of various experimental paradigms, we uncover aspects of memorability that highlight its susceptibility to contextual influences. Notably, our investigation revealed that within the domains of recall and recognition experiments, there exists a high degree of internal consistency, indicative of the reliability of these paradigms in assessing memorability. However, the strikingly low correlation observed between these two paradigms underscores the relationship between memorability and the specific experimental context. This divergence from conventional assumptions necessitates a re-evaluation of memorability, subject to fluctuation under varying experimental constraints.

Discussion

We have demonstrated that while recall and recognition experiments exhibit high internal consistency, the correlation between these inter-paradigms remains significantly low. This implies that the memorability of information is deeply entwined with the specific experimental context. Note that our findings pertain to the population concept of word memorability (assessed across participants, and thought to reflect an intrinsic property of the word). Therefore, our findings challenge the conventional notion of memorability as an intrinsic property of a stimulus. Instead, they underscore the critical importance of considering the experimental context when interpreting memorability results. While one could anticipate this result from the wellknown and differential influences of word frequency and other word properties on recall and recognition, in the domain of memorability, there is inadequate consideration of the role of the memory testing format. In the next steps, we will further test whether the discrepancy in memorability scores across memory tests reduces when removing the confounding influence of word frequency by considering only the words that are neither too rare nor too common.

# Unsettled Minds, Unpredictable Choices: The Influence of Trait Anxiety On Reward Accumulation in Volatile & Stochastic Environments

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Introduction

While learning about uncertain situations involving hidden & dynamic environmental processes, the learning rate is not only influenced by external environmental uncertainties but also by internal states, like the anxiety level of the individual (Pulcu & Browning, 2019). Notably, highly anxious individuals have been hypothesized to incorrectly attribute random variations (stochasticity) to true variations or volatility (Pulcu & Browning, 2019; Piray & Daw, 2021).

Specifically, trait anxiety, a relatively stable personality attribute than the transient state anxiety, serves as a significant 'vulnerability factor' for anxiety-related psychopathologies (Saviola et al., 2020). Individuals with high trait anxiety have shown to exhibit reduced cognitive & behavioral flexibility i.e., the ability to adapt one's thoughts & responses to changes in the environment (Knowles et al., 2020).

While previous studies have systematically manipulated the magnitude of stochasticity (McGuire et al., 2014; Nassar et al., 2016) or volatility (Browning et al., 2015; Pulcu & Browning, 2017), independently, a comprehensive understanding of how anxiety causes the confusion between these factors necessitates a joint manipulation of both (Piray & Daw, 2021). Whether & how learning rates change in scenarios where both stochasticity & volatility are nested remains unclear, as does the influence of anxiety on learning in such circumstances.

This study delves into the impact of anxiety on decision-making & learning when individuals are exposed to varying levels of both stochasticity & volatility. By examining the interplay of these factors, the research aims to shed light on: 1) whether individuals differentiate between stochasticity & volatility. And 2) if high trait anxious individuals overestimate volatility, while avoiding underestimation of stochasticity.

Methodology

50 young adults from IIT Kanpur participated, with 2 excluded for low alertness on the Stanford Sleepiness Scale. Anxiety scores were assessed using the State Trait Anxiety Inventory (STAI-Y), categorizing individuals as high trait anxious (HTA, STAI-T subscale ≥ 45), or low trait anxious (LTA) based on previous research, that classified scores falling between 45-80 as "high trait anxiety" (Kayikcioglu et al., 2017; Bunevicius et al., 2013). We also performed k-means clustering & found 2 distinct clusters at the 45th mark. Employing this categorization aids in clustering individuals into 2 groups for better comprehension.

Using a 3x2 repeated-measures design, participants made decisions on rewarding patches in 6 environments varying in stochasticity (60%, 70%, 80%) & volatility (fast, slow). In each trial (N=50), 3 patches probabilistically provided rewards (smiley emoji), with the most rewarding patch at 80%, 70%, or 60% (see Fig.1). Reward contingencies switched after 25 (slow) or 10 (fast) trials for volatility (see Fig.2). The 6 blocks were: 80Fast, 80Slow, 70Fast, 70Slow, 60Fast, 60Slow, with counterbalanced block order.

Results

Do volatility & stochasticity impact task performance?

We expected both factors to reduce reward accumulation by hindering the identification of the most rewarding patch. A two-way repeated measures ANOVA on total rewards confirmed this, with significant main effects of stochasticity & volatility (Stochasticity: $F(2, 94) = 87.15$, $p<.001$, $\eta2p= 0.65$; Volatility: $F(2, 47) = 6.96$, $p<.001$, $\eta2p= 0.13$), see Fig. 3a. A mixed logistic model further revealed that as stochasticity & volatility increased, the probability of identifying the best patch decreased (60%: $\beta = -0.49$, 95% CI [-0.56, -0.41], $p< .001$; 70%: $\beta = -0.36$, 95% CI [-0.43, -0.28], $p<.001$; Fast: $\beta = -0.27$, 95% CI [-0.34, -0.20], $p<.001$). Significant two-way interaction was only found between 70% stochasticity & fast volatility ($\beta = 0.11$, 95% CI [0.00642, 0.22], $p<.05$), see Fig. 3b.

How does anxiety affect task performance?

We hypothesized that HTA individuals overestimate volatility in slow volatility-high stochasticity conditions, leading to fewer rewards. A three-way non-parametric rank-based ANOVA between volatility, stochasticity, & trait anxiety (high/low) revealed a significant main effect of trait anxiety in lowering reward accumulation ($F(1,276) = 4.076$, $p<.01$, $\eta2p= 0.015$), alongwith main effects of stochasticity & volatility. While no significant three-way interaction were observed, significant two-way interaction emerged between trait anxiety & volatility ($F(2,276) = 4.866$, $p<.01$, $\eta2p = 0.017$), see Fig. 4a. HTA had lower rewards than LTA in slow volatility, & volatility changes significantly affected LTA. Similar trends were also observed when HTA cut-off was set to mean split (M=44) as well as when trait anxiety was on a continuous scale.

To further investigate these findings, we computed a trial-wise cumulative learning score in identifying the best patch for all blocks. Using a Bayesian zero-one inflated beta regression that best captured learning scores, we developed a mixed regression model. Again, an increase in all three factors led to a reduction in the learning score especially with increased stochasticity, slow volatility, & elevated trait anxiety (e.g., HTA 60Slow), see Fig. 4b. Two-way interactions indicated that high-anxiety individuals' performance was notably impaired in slow volatility but high stochasticity condition.

What leads to low performance & rewards in HTA?

To grasp the underlying mechanisms, we modeled the task behavior using a reinforcement learning model (for learning) & a drift diffusion model (for decision-making) using the HDDM package (Perderson & Frank, 2020). As expected learning rates from positive prediction errors increased in low volatility & low stochasticity conditions; for instance, 92% of individuals displayed this effect as calculated based on the posterior distribution when comparing 80slow vs 60slow i.e. P(80S > 60S) = 0.92. While, learning from negative prediction errors increased in low volatility but high stochasticity blocks [80S < 60S = 85%]. These adaptations could underlie the lower reward accumulation in high volatility & stochasticity blocks. As expected, the drift-rate increased in low volatility & low stochasticity blocks reflecting higher value difference between patches [80S > 60S = 100%]. While decision thresholds rose in high volatility but low stochasticity blocks reflecting higher caution [80F > 60F = 87%]. Thus, in less stochastic environments, the decision about rewarding patches were made with more decisiveness. When environmental contingencies were rapidly changing (fast volatility), decisions were made slower & with higher caution because of the weaker signal, as expected.

Adding anxiety to the model, we found that HTA displayed lower learning rates from positive prediction errors [e.g., HTA 60S < LTA 60S = 71%] & higher learning rates from negative prediction errors than LTA [e.g., HTA 60S > LTA 60S = 70%]. For fast volatile (80F, 70F, 60F) conditions, HTA displayed drift-rates similar to LTA, but for slow volatile (80S, 70S, 60S) conditions their drift-rates were lower than LTA (e.g, drift-rate: HTA 80S < LTA 80S = 88%). With regards to threshold, they were less cautious in all blocks than LTA [e.g., threshold: HTA 80S < LTA 80S = 87%] except in high stochasticity blocks [threshold: HTA 60S > LTA 60S = 63%, HTA 60F > LTA 60F = 81%] & in 80fast they had similar threshold to LTA. Specifically, for 60slow blocks we observed that HTA were making decisions more cautiously & accumulating evidence at a slower rate than LTA. Model recovery using 10 synthetic datasets (N = 50, trials = 300 each per block for all the 6 blocks), found that our model was able to sufficiently recover the true parameters we provided.

However, we also noticed that threshold & positive learning rate were higher when volatility & stochasticity were higher – suggesting systematic misinterpretation of stochasticity for volatility across all individuals. With regards to anxiety, HTA had higher drift-rates in 70fast blocks, higher threshold when stochasticity was 60%, & lower negative learning rates in 70fast & 60fast blocks. We aim to investigate these further.

Discussion

Task performance suffered due to stochasticity & volatility. Lower reward accumulation was linked to trait anxiety, particularly in slow-volatile, high-stochastic settings. While learning about the most rewarding patch, stochasticity and volatility interacted along with anxiety. In these environments, greater sensitivity to negative feedback, followed by less decisive but more cautious decisions to switch may underlie suboptimal behavior; possibly due to strong expectation violation. Future research will explore the interactions further and employ hierarchical gaussian filters to examine the process behind the switch among anxiety groups.

**Development of Optical Memory Devices to Mimic Human Brain Functionality using Neuromorphic Computing**

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The conventional computing architectures are working based on the von Neuman architectures. There is a bottleneck in this architecture: memory and processing units are physically separated due to this it requires a lot of energy for the computation and latency [1]. In contrast to this architecture, the human brain processes 1012 neurons and 1015 synapses to process/store the information in a parallel, massive manner [2]. Recent computing technologies inspired from the brain multitasking abilities (low power consumption efficiency, self-learning capability, fault-tolerant operation, etc.) designed different architectures like memristors and synaptic transistors. The computing technology based memristors architectures have drawn research attention due to their exceptional features such as small size, ease of fabrication, low energy required for computation, ultrafast speed, high endurance, high ON/OFF ratio, long retention time, and CMOS integrability etc. Memristors based devices are used in different applications such as neuromorphic visual systems, optogenetics, arithmetic computing, brain-inspired computing, etc. [3,4]. However, these memristors devices have used electrical stimulation to change their resistance state (high resistance state (HRS) to low resistance state or (LRS)). These devices have certain functional limitations like trigger selectivity, electrical interconnect power loss, spatially confinement [5]. To overcome this limitation, optical signals are used as a stimuli to stimulate the memory device functionality due to their special characteristics such as fast propagation speed, high bandwidth etc. [6]. It is well known that the fabrication methods and selection of the active layer plays a major role in the overall performance of the memory device. The first and foremost step to select the appropriate active material. There are different wide band gap materials like transitional metal oxides and transitional dichalcogenides etc. After the selection of the active material in the next step we are trying to optimize the thickness and fabrication environment etc. This main objective of the work is to demonstrate micro/nano size wafer scalable optical memory devices with high retention time. Retention time is one of the important performance metrics of the memory devices. In this context, to improve the performance metric, this work introduces the micro/nano MoS2 based optical memory devices. These optical memory devices were fabricated using the standard wafer scalable microfabrication techniques.

The device fabrication starts with P-type crystalline silicon wafer (orientation of <100> and resistivity of 1-10 Ω-cm) was used as a substrate to fabricate the devices. Further, an oxidation layer (300 nm) was grown on the substrate using standard thermal oxidation process. Further, RF sputtering was used to deposit a thin layer of Mo followed by oxidation at 500 oC for 1 hour. This process yields the formation of MoO3 on SiO2/Si substrate. After that, MoO3 decorated samples were sulfurized at 600 ◦ C for 20 minutes. During the sulfurization process The MoO3 sample and sulfur were placed inside the three-zone quartz furnace and in the presence of nitrogen. The process resulted in the formation of MoS2 on SiO2/Si substrate. In the final step, metal contacts (Cr/Au) were made using sputtering through shadow masks. Further, atomic force microscope (AFM) and Raman spectroscopy analysis was performed to examine the topographical and structural properties of the fabricated MoS2. During the AFM analysis we have confirmed that the MoS2 was grown uniformly on the substrate. Raman peaks occurred at 383 and 408 cm−1 correspond to the E2g and A1g vibrational modes of the MoS2. Further, the fabricated samples were tested as photonic devices using a source measurement unit (2614 B). These fabricated photonic devices are able to mimic the important human brain functionalities like paired-pulse facilitation (PPF) index, excitatory postsynaptic current (EPSC), long term potentiation (LTP) and short term potentiation (STP) etc. These devices have shown the PPF index of 234 % and retention time of 1.4 × 103 seconds. In addition to this, the fabricated device's potentiation and depression experimental data convoluted with modified national institute of standards and technology (MNIST) dataset to recognize the digits. To further improve the device performance this work extended toward the advanced fabrication technologies. Electron beam lithography (EBL) etc. and different active materials which may help to enhance the overall performance and the quality/uniformity of the films. We have already demonstrated devices with the explained concept and more research towards the optimization of the thickness of the active layer is under progress.

# Curious to explore? Role of Feedback, Confidence Error, and Academic Motivation

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Introduction

Knowledge exploration refers to the active pursuit of information, ideas, and experiences, often beyond the boundaries of current task demands. It is the desired behaviour resulting from various motivational states such as curiosity, interest, and engagement. Exploration plays a vital role in driving advancements in our society, serving as a fundamental catalyst for learning as well as new discoveries. Researchers have conceptualized knowledge exploration as the process of seeking out and discovering new information (Liu et al., 2010). It is a continuous and active process that governs how individuals connect with and learn from their surroundings. A wide range of long-term activities, including seeking for, consulting with, creating, and responding to new opportunities, are referred to as "exploring activities" (Kraiprasit & Bhanthumnavin, 2022). Previous research on exploratory behaviour has predominantly focused on visual and perceptual forms of exploration, overlooking the academic aspect, where the aim is to bridge knowledge gaps (Trevors et al., 2017). We used these research questions to direct our investigation: 1. How does the presence of feedback in a low-stake learning environment affect students' knowledge exploration? 2. How do the feeling of confidence and confidence error influence real-time knowledge exploration? 3. What is the role of intrinsic and extrinsic academic motivation on students' knowledge exploration?

Methods

The purpose of the study was to understand real-time knowledge exploration among high school students. We used a low-stake experimental task-based paradigm (in E-Prime) where 100 students (48 female, 52 males) were exposed to a variety of questions in two sessions of 15 trials each (age 13-17 years, M 14.70 years, SD 0.78). The informed consent of the volunteering students and their parents was obtained. We remarked that there was no performance judgment associated with the task. Figures 1 and 2 present the experimental framework for sessions 1 and 2, respectively. In session 1, multiple-choice questions were presented in random order, and respondents were asked to choose the correct answer. Then students had the option to choose between three options: (a) move to the next question indicating no motivation to explore; (b) see the correct answer; (c) see the detailed answer indicating motivation for detailed exploration. When the participant chose the third option, they were presented with a detail about the topic on a single screen where they could learn about the topic and the rationale for the correct answer. Session 2 was similar to Session 1 with two additions; immediately after the response, participants were asked to indicate their confidence in the answer, followed by performance feedback.

Results

The data are organised hierarchically into two levels, with questions at Level 1 [L1] nested within Individuals (Level 2 [L2]). Using Mplus 8 (Muthén & Muthén, 2017), we modelled within- and between-person relations in these nested data using multilevel ordinal logit regression modelling to estimate the relationship. Results indicated a significant negative relationship between accuracy and knowledge exploration, suggesting that knowledge exploration was more likely to occur with incorrect answers. Moreover, the impact of incorrect answers on knowledge exploration was stronger in session 2 (when feedback was provided) than in session 1 (when feedback was not provided) (Session 1: $\beta = -0.236^{**}$ Session 2: $\beta = -0.705^{**}$). The interaction between accuracy*FOC ($\beta = -0.179^{**}$) was a significant negative predictor of knowledge exploration, indicating that confidence errors triggered knowledge exploration among students. The addition of between-level variables improved the prediction of knowledge exploration above and beyond the within-level variables included in the model. Intrinsic-motivation positively predicted knowledge exploration ($\beta = 0.388^{**}$). Interestingly, extrinsic-motivation negatively predicted knowledge exploration ($\beta = -0.338^{**}$).

Discussion

Our findings suggest that even in the absence of feedback about accuracy, students were strongly motivated to explore wrong responses. This indicates that students are naturally eager to learn and take the initiative to explore and correct their errors, even without external feedback. However, giving accurate feedback after each trial significantly increased students' knowledge exploration, especially when they gave erroneous responses. Lower accuracy triggers an experience of knowledge gap and helps students to fill that gap. Therefore, feedback can be particularly effective when students struggle with the task and may need more support to develop their understanding. Higher confidence in incorrect answers was associated with higher knowledge exploration. The result is consistent with previous studies suggesting that errors can promote deeper processing of information. Individuals are more likely to learn from their mistakes when they are confident in their incorrect answers, leading to increased metacognitive awareness and more effective learning. This effect known as the hypercorrection effect (Vogl et al., 2019), indicates that errors accompanied by higher confidence have a greater probability of getting rectified in a final test than errors accompanied by lower confidence. Intrinsically motivated students

exhibit a natural curiosity and zeal for learning, while students driven by external rewards may lack the motivation to engage in knowledge exploration when such rewards are absent. These findings have significant implications for education. Educators can enhance learning by fostering error-making and feedback opportunities while also structuring course materials to boost metacognitive awareness, promoting deeper engagement and better learning experiences.

**Bilingualism and cognitive reserve: Exploring neural basis in frontotemporal dementia**

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Introduction

Recent evidence suggests that modifying risk factors by using effective strategies across the lifespan may prevent or delay up to 40% of dementias through enhancing cognitive reserve[1]. Cognitive reserve is the ability of the brain to maintain cognition in the presence of neurodegeneration[2]. Over the last decade, bilingualism has been demonstrated to be a promising lifecourse factor that could enhance cognitive reserve. Evidence for this association came initially from studies showing that bilingualism delays age at onset of dementia symptoms[3]. However, the neural basis of this protective effect remains elusive. Cognitive reserve in the context of bilingualism and Alzheimer's disease has shown lesser cortical thickness, increased hypometabolism, and reduced volume of the brain in bilinguals while maintaining similar levels of cognition compared with monolinguals[4]. So far, no study has reported a neural mechanism of bilingualism based cognitive reserve among persons with frontotemporal dementia (FTD). Therefore, the present study aims to investigate the neural basis of cognitive reserve in bilinguals with FTD.

Methods

Participants:

68 persons with a diagnosis of FTD (42 bilinguals and 26 monolinguals) and 40 cognitively normal individuals who did not differ in age, sex and education were recruited. All participants were right handed. 50 participants were diagnosed as behavioural variant FTD and 18 were primary progressive aphasias. The participants were considered as bilinguals if they met communicative demands in more than one language[5]. Cognition was evaluated using Addenbrooke's Cognitive Examination (ACE)-III. The Clinical Dementia Rating (CDR) scale was used to determine the severity of dementia.

Propensity score matching:

A significant challenge to the studies on bilingualism, brain and cognition is the effect of confounding variables[6]. We employed propensity score matching technique to mitigate the potential effect of confounders. Considering age, sex, education, FTD subtypes and severity of dementia, the optimal matching algorithm matched the bilingual FTD group with the monolingual FTD group in a 1:1 ratio, yielding 26 bilinguals and 26 monolinguals.

MRI acquisition and processing:

All participants underwent magnetic resonance imaging (MRI) using a 3 Tesla Skyra MR scanner. The T1-weighted images of each participant were initially inspected for any inhomogeneity or movement related artifacts. The pre-processing was performed using the default pipeline focused on voxel-based morphometry in the Computational Anatomy Toolbox (CAT12;  The conventional computing architectures are working based on the von Neuman architectures. There is a bottleneck in this architecture: memory and processing units are physically separated due to this it requires a lot of energy for the computation and latency [1]. In contrast to this architecture, the human brain processes 1012 neurons and 1015 synapses to process/store the information in a parallel, massive manner [2]. Recent computing technologies inspired from the brain multitasking abilities (low power consumption efficiency, self-learning capability, fault-tolerant operation, etc.) designed different architectures like memristors and synaptic transistors. The computing technology based memristors architectures have drawn research attention due to their exceptional features such as small size, ease of fabrication, low energy required for computation, ultrafast speed, high endurance, high ON/OFF ratio, long retention time, and CMOS integrability etc. Memristors based devices are used in different applications such as neuromorphic visual systems, optogenetics, arithmetic computing, brain-inspired computing, etc. [3,4]. However, these memristors devices have used electrical stimulation to change their resistance state (high resistance state (HRS) to low resistance state or (LRS)). These devices have certain functional limitations like trigger selectivity, electrical interconnect power loss, spatially confinement [5]. To overcome this limitation, optical signals are used as a stimuli to stimulate the memory device functionality due to their special characteristics such as fast propagation speed, high bandwidth etc. [6]. It is well known that the fabrication methods and selection of the active layer plays a major role in the overall performance of the memory device. The first and foremost step to select the appropriate active material. There are different wide band gap materials like transitional metal oxides and transitional dichalcogenides etc. After the selection of the active material in the next step we are trying to optimize the thickness and fabrication environment etc. This main objective of the work is to demonstrate micro/nano size

wafer scalable optical memory devices with high retention time. Retention time is one of the important performance metrics of the memory devices. In this context, to improve the performance metric, this work introduces the micro/nano MoS2 based optical memory devices. These optical memory devices were fabricated using the standard wafer scalable microfabrication techniques.

The device fabrication starts with P-type crystalline silicon wafer (orientation of <100> and resistivity of 1-10 Ω-cm) was used as a substrate to fabricate the devices. Further, an oxidation layer (300 nm) was grown on the substrate using standard thermal oxidation process. Further, RF sputtering was used to deposit a thin layer of Mo followed by oxidation at 500 oC for 1 hour. This process yields the formation of MoO3 on SiO2/Si substrate. After that, MoO3 decorated samples were sulfurized at 600 ◦ C for 20 minutes. During the sulfurization process The MoO3 sample and sulfur were placed inside the three-zone quartz furnace and in the presence of nitrogen. The process resulted in the formation of MoS2 on SiO2/Si substrate. In the final step, metal contacts (Cr/Au) were made using sputtering through shadow masks. Further, atomic force microscope (AFM) and Raman spectroscopy analysis was performed to examine the topographical and structural properties of the fabricated MoS2. During the AFM analysis we have confirmed that the MoS2 was grown uniformly on the substrate. Raman peaks occurred at 383 and 408 cm−1 correspond to the E2g and A1g vibrational modes of the MoS2. Further, the fabricated samples were tested as photonic devices using a source measurement unit (2614 B). These fabricated photonic devices are able to mimic the important human brain functionalities like paired-pulse facilitation (PPF) index, excitatory postsynaptic current (EPSC), long term potentiation (LTP) and short term potentiation (STP) etc. These devices have shown the PPF index of 234 % and retention time of 1.4 × 103 seconds. In addition to this, the fabricated device's potentiation and depression experimental data convoluted with modified national institute of standards and technology (MNIST) dataset to recognize the digits. To further improve the device performance this work extended toward the advanced fabrication technologies. Electron beam lithography (EBL) etc. and different active materials which may help to enhance the overall performance and the quality/uniformity of the films. We have already demonstrated devices with the explained concept and more research towards the optimization of the thickness of the active layer is under progress. ). The statistical analyses were performed using SPSS version 26.

Results

FTD was associated with atrophy of frontotemporal regions along with bilateral fusiform gyrus, caudate nucleus and left putamen. There were no significant differences between bilinguals and monolinguals in their age (p = .633), distribution of males and females (p = .262), FTD subtype (p = .749) duration of disease (p = .317), dementia severity (p = .356) or cognitive performance (p = .439). Bilingualism was associated with greater loss of bilateral thalamic volume even after controlling for age, sex, years of education, dementia severity and total intracranial volume (left thalamus: F (1, 45) = 7.11, p = .011, ηp2= .136; right thalamus: F (1, 45) = 8.22, p = .006, ηp2= .155). An interaction effect between bilingualism and dementia severity (left thalamus: F (2, 40) = 6.90, p = .003, ηp2= .256; right thalamus: F (2,40) = 6.05, p = .005, ηp2= .232) revealed a negative relationship between thalamus volume and dementia severity only among bilinguals with FTD (left thalamus: b = -.839, p = .001; right thalamus: b = -.784, p = .001).

Discussion

Bilinguals with frontotemporal dementia had reduced bilateral thalamic volume in comparison to their monolingual counterparts, despite demonstrating similar cognitive ability. Bilinguals also showed steeper decline of thalamic volume as a function of severity of the disease. This indicates that bilinguals may endure greater atrophy of the thalamus than monolinguals, potentially owing to more efficient cognitive processing mechanisms[7]. Our results suggest that bilingualism is related to better cognitive reserve in the presence of FTD pathology.

High frequency of switching is a characteristic feature of the multilingual Indian population which requires conflict resolution and response selection. The thalamus aids in selecting the appropriate words from the mental lexicon in bilinguals by engaging with right inferior frontal gyrus, caudate and putamen[8]. According to the predictions of the Dynamic Restructuring Model[9], it is expected that the thalamus contracts following the peak efficiency stage of second language proficiency, especially in a population known for higher switching frequencies. Our study shows that this effect of lifelong bilingualism is reflected even in the diseased state. To conclude, this study lends support to the theory that the early recruitment of executive and attentional control in bilinguals facilitate protective mechanisms in the presence of neurodegenerative disease pathology[10].

## Towards developing a functional localiser for letter-specific brain responses for Bangla: An MEG Study

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Introduction:
Earlier MEG studies have demonstrated that two primary neural responses to written words are (i) an early sensitivity to low-level physical properties ("Type One" responses) and (ii) a later letter-specific response ("Type Two" responses), which differentiates between words vs. symbol strings regardless of their physical properties. These processes occur in the first 200ms of recognizing a word and are localized in the left fusiform gyrus, or Visual Word Form Area (VWFA) [1]. These responses can be identified using a functional localizer which compares words vs. non-linguistic symbols embedded in levels of Gaussian noise, yielding distinct Type One (noisy vs. non-noisy) and Type Two (letters vs. symbols) responses [1,2]. However, this work predominantly relies on European languages written in the Roman script, and no such localizer has yet been built for Indic languages. The present study builds on the earlier works and bridges this gap. The main objective is to develop and validate a functional localizer to identify word-specific brain responses for an Indic language, Bangla, an understudied language written in an abugida, a writing system in which vowels are added to consonants as diacritics which may occur above, below, or on either side of a consonant.
Methods: Twenty-three right-handed self-reported native Bangla speakers with normal or corrected-to-normal vision participated in the study. Continuous recording of MEG data was performed using a 208-channel axial gradiometer system at a sampling rate of 1000 Hz. The experiment was a passive-looking task. Stimuli were presented in a within-subjects 2 × 2 × 2 design, manipulating String Type (Bangla letters, non-linguistic symbols), Length (one symbols, four symbols), and Gaussian noise (Level 1, Level 24), totaling 300 stimuli, (see Fig. 1). A fixation cross (+) first appeared at the centre of the screen for 1000ms, followed by a 60ms display of stimuli with an interstimulus interval of 2000ms. The experiment lasted 10 minutes.

Results:
We report here on Type Two only. For source localization; we conducted two-stage regression analyses, fitting a regression to each time and source point. We identified significant clusters using spatiotemporal cluster-based permutation tests computed on t-statistics from one-sided t-tests on regression beta values (see Fig 2 for source localization analyses) [3]. Regressions consisted of String Type and Gaussian Noise; spatiotemporal clustering was conducted in left and right occipitotemporal regions in time window 150–200ms, selected by visual inspection of averaged waveforms. Three significant clusters of Letter vs. Symbol were identified. Two were identified in right medial-anterior fusiform gyrus, one from 150–189ms ($p < 0.01$, Fig 2-A) and another 157–198ms ($p = 0.01$, Fig 2-B). Both of these showed greater negative activation for Letter stimuli. Another cluster was identified in left posterior fusiform gyrus at 163–197ms ($p = 0.01$, Fig 2-C), with greater positive activation for Letter stimuli. No clusters for Noise were identified.

Discussion:
Our study conclusively demonstrates that word-specific brain responses can be identified in the Indic language Bangla using a functional localizer developed and validated through MEG data. Our results are consistent with earlier "Type Two" findings replicating the canonical activation direction previously found in English, Greek, and Finnish [1, 2, 4]. Our spatiotemporal cluster-based permutation tests reveal that visual word-form responses initiate in the right hemisphere regions and are subsequently detectable in the left hemisphere. These findings demonstrate a bilateral 'visual word form area' for Indic languages, and this functional localizer can be used for further studies investigating lexical and morphological processing in Bangla. The hemispheric differences in our results could arise from the difference in orthography for Bangla (abugida script) compared to the previous studies using alphabetic scripts. Overall, our study significantly contributes to understanding the spatiotemporal extent of "Type Two" neural responses in localizing early character string processing to the fusiform gyrus for use as an fROI for future experiments in an understudied language like Bangla.

# Does dependency length minimisation hold during dialogue?

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Introduction

Dependency Length Minimization (DLM) has been shown to be a cross-linguistic constraint on word order variation[9,4]. DLM posits that two syntactically related words would appear in close proximity, such that it can optimise limited memory resources – establishing a dependency relation between two words will typically require memory retrieval (of the head or the dependent) [5,8]. This implies that sentences with shorter dependencies will, on average, be easier to process with less cognitive cost.

Evidence favouring DLM is typically based on large-scale corpora generally from the news genre [9,4,6], i.e. written data. Hence, it is unclear if the DLM constraint would also hold in naturalistic spoken data. While both speaking and writing involve the production apparatus, they may not be operating under similar constraints. For instance, the production system can be assumed to be under more time pressure when speaking than writing (where there are generally many edits to a sentence). Thus, it is reasonable to assume that the DLM constraint might be more evident in written text where the writer tries to achieve high readability. While in speech, other pressures related to incrementality, accessibility, etc., could supersede the DLM constraint.

Another intriguing finding in the literature is that while DLM functions cross-linguistically, it is not as strong in all languages. It has been discovered, for example, that the influence of DLM is modest in Subject-Object-Verb (SOV) languages [3]. Indeed, recent research using news data indicates that DLM is marginal in predicting word order variance in an SOV language like Hindi[10]. Given these findings, DLM possibly may not be observed in speech data, especially in SOV language. This work investigates this issue using a newly developed Hindi dialogue corpus.

Method

Data

We use the IIT Delhi Hindi Dialogue Corpus. The dialogue data was acquired from the Linguistic Data Consortium (LDC) and consisted of multiple telephonic conversations between friends. The data was manually transcribed and later was (semi-)automatically annotated for part-of-speech and syntactic dependency relations, which were finally validated manually. As this is an ongoing work, the current study is based on partial data comprising 23947 sentences. We further subset this data to exclude sentences with lengths less than 3 and more than 191. This left us with 13269 sentences for analysis. The average sentence length in this data was 7.13; see Figure 1.

Random Baselines

Following [13], we generate random linear arrangement baselines (RLAs) from the real trees of the Hindi Dialogue Corpus. The algorithm chooses a random baseline tree from a uniform distribution of random linearisation of a real tree through a rejection sampling method. The random tree is controlled for sentence length, the number of crossing dependencies and all topological properties to obtain a strict baseline. We then compare the real and random trees to test if the average dependency length between the two trees differs. (for more details, see [13]).

Analysis

We are interested in two questions: (1) Is DLM observed in Hindi during naturalistic speech, and (2) is there a difference between DLM in speech vs text? To investigate these questions, we carried out two sets of analyses. The first analysis tested the extent of DLM in speech corpus. We want to test whether the distribution of dependency length is significantly different between real trees and the baseline trees. For this, we compared the growth of dependency length with sentence length. If DLM holds in speech data, then the dependency length in real trees should increase slower with respect to sentence length compared to the random baseline. We fit a linear mixed-effects model with dependency length as the dependent variable, the sentence length (scaled)2 and tree type (real or random) as the fixed effect, and speaker ID as the random effect. Maximal models were fit subject to model convergence[1]. We use a similar model for the second analysis with an additional covariate Modality (Dialogue vs Written) to see the interaction effect. We use the HUTB corpus [2] for the written text.

Results

Results show that the average dependency length grows slower with sentence length in real trees compared to random trees (t-value=-22.05); see Table 1 for details. The second analysis showed no significant difference in the increase of dependency length in the two text types: dialogue and text (t=-1.386); see Table 2.

Discussion

The study's key findings are (a) there is evidence of DLM in the Hindi Dialogue corpus, and (b) there is no significant difference in speech vs written text for DLM. This suggests DLM as a processing constraint in an SOV language like Hindi across modalities.

The DLM constraint in the speech data has implications for the incrementality model of production. In particular, DLM implies the structural planning of a sentence's arguments to ascertain the linear order or at least the notion of placing the shortest dependency next to the verb [11], which is motivated by the efficiency principle. Due to such proximity, speakers can retain arguments from working memory easily. Thus, planning during language production is non-incremental to a certain degree. However, incrementality in production and the effect of factors such as accessibility cannot be discounted. Another possibility is that shortening dependency distance in speech may not reflect the above-mentioned planning-related strategies. Instead, it is a fallout of widespread elision during dialogue [7]. We intend to investigate this issue in the near future.

Given the differences in pressures in the two domains, the absence of variation in dependency length in dialogue and written text was surprising. A possibility is that the production system works the same way in both modalities [12]. Another possibility is that DLM strategies are distinct in written and spoken text, as cognitive difficulty may differ in both modalities. Moreover, argument ellision could be a common source of dependency shortening in dialogue, whereas other planning vital processes could be in written text. The question is how cognitive cost is related to longer dependency. We aim to analyse it further.

Broadly, these results highlight the role of working memory constraints and cognitive load during comprehension and production in an SOV language like Hindi.

# Engagement of cognitive control in code-switching during auditory comprehension having conflict and non-conflict conditions

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Introduction

Conflict adaptation is the effect that people are better at resolving a conflict if it is immediately preceded by another conflict (Ullsperger et al., 2005). Performing a non-linguistic task better in terms of RT after being involved in a code-switch has been shown by some previous studies (Adler et al., 2020, Bosma & Pablos, 2020, Wu and Thierry 2013, Jiao et al., 2019). For instance, Adler et al. (2019) showed that comprehending one sentence with a code-switch in the middle improved the performance in the subsequent incongruent Flanker trials. These results were explained using the congruency sequence effect or CSE which is the reduced congruency effect after an incongruent trial compared to a congruent trial (Weissman and Bissett, 2017). In the current study, we investigated the role of executive control in switching from L1 to L2 during comprehension at the word level using a conflict adaptation paradigm. Three types of switches were considered: English to English(No switch), Hindi to English(Switch), and Hindi to Biased English words(Switch), presented through an auditory lexical decision task. Biased words in English are those which has no corresponding translation in Hindi. We compared the performances in a Saccadic Stroop task after encountering each of these switch types (EE, HE, and HB). We expected to see smaller saccade latencies on those incongruent trials followed by a switch (HEI) compared to no-switch (HHI). Moreover, in the case of switch to a biased word (HBI) would not tap any such control mechanisms given the lack of any competitors in that case.

Methods and Procedure:

We considered highly frequent Hindi and English words (English: 4.12 (0.39), Hindi: 4.12 (0.41) on a 5-point Likert scale). Duration was also balanced between different word sets (English: 1002.3ms (96.05), Hindi: 976.14ms (93.35), Biased: 997.46ms (102.6)). We had 84 critical stroop trials, 50% congruent and 50% incongruent, each preceded by either an English-English pair or a Hindi-English pair or a Hindi-Biased pair hence 28 (14 congruent and 14 incongruent) conditions in each. We collected 31 participants (23 female) who were equally proficient in both Hindi and English (Lextale: 70.56% (SD=5.47) and Hilex: 75.68% (SD=6.55)).

Results

In ALDT, participants responded faster to words (M=1277, SD=232) compared to non-words (M=1616, SD=274) with a significant difference between them ($t(31) = 9.34$, $p < 0.05$). Switching cost was absent ($t(31)=1.473$, $p>0.05$). But we found significant difference between switch condition and biased switch condition ($t(31)=3.957$, $p>0.05$) (Figure 1). Also, there was no significant difference in RT for English (M=1271, SD=194) and Hindi (M=1283, SD=310) words, $t(31) = 0.312$, $p > 0.05$. A 2-way repeated measures ANOVA on Stroop reaction time with congruency (Congruent and Incongruent) and switch type (English-to-English, Hindi-to-English, and Hindi-to-Biased) as within-subject variables showed a main effect of congruency, $F(1,30) = 41$, $p <.05$, $\eta 2 = 0.58$ (Figure 2) such that saccade latencies were smaller for congruent than incongruent trials. However, both switch type and interaction showed no significant effects.

Discussion

The results from the ALDT showed that no difference in the RTs for English (l2) switched and non-switched trials, thus showing switching cost during auditory code-switching. However, a significant difference between switch and biased-switch condition was found which shows participants were faster to biased English words compared to English words. Accessing Biased words were easier than even L1. Since, participants were equally proficient in both English and Hindi, this switch-cost absence was intuitive (Tse et al., 2015). To test the engagement of cognitive control during switching we specifically looked at incongruent trials because they involve conflict, unlike congruent trials. The results showed no difference in the response latencies to the incongruent trials preceded by switched or no-switch condition. In our case, the absence of switching costs during code-switching can account for why the performance in incongruent trials was comparable between the switch and no-switch conditions. Proficiency is a major factor in bilingual tasks and it influences switching costs and other bilingual advantages. Another potential reason could be small sample size was the number of critical trials was less.

**Motion event-based Cross-linguistic typological study of Gesture and Speech: the case of Telugu.**

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The intricate relationship between language and cognition has been a central focus of our research,prompting anexploration ofthe intricateconnections betweenlinguistic expression and human thought. This study is centered on Telugu, a Dravidian language known for its uniquelinguistic features,offering acompelling perspectiveto examinethe interplaybetween language and thought, with gestures as a medium of exploration. Recognizinggestures asa powerful"window onthe mind"(Susan Goldin-Meadow,2007), we have leveraged them as a vital tool in our research. This viewpoint aligns with broader scholarship, suggesting that gestures can reveal insights that transcend spoken communication (Kelly, 2008) and that language structure plays a pivotal role in shaping cognition (Boroditsky, 2000, 2001, 2008). Thecentral researchquestion revolvesaround theimpact oflanguage ongestures andthought expression, particularly in motion contexts. This investigation stems from the motivation to explorehow Telugu'sunique linguisticcharacteristics, distinctfrom languageslike Turkish and English, influence gesture patterns. The rationale lies in acknowledging that different culturesand languagesexhibit varyinggestural patterns,emphasizing theneed tounderstand the baseline similarities and differences across linguistic contexts.

Building uponprevious studies(Kita &Özyürek, 1999,2003) thatcompared satellite-framed (English) and verb-framed (Japanese, Turkish) languages, we aimed to uncover parallels between linguistic expression and gestural representation. However, our research takes a unique pathguided byinsights intoTelugu's intricatelinguistic framework(V. Naidu,2018).

Wedelve intothe dynamiclanguage-gesturerelationship inTelugu, atypologically distinct language knownfor itsunique patternsof motionevent encoding.Telugu speakersdefine the path of motion using Direction verbs, Case marking, and Adnominal strategies, raising questions about how they gesture for the same and which semantic types they gesture the most. Additionally,we alsoinvestigated differencesin gesturepatterns betweensingle-clause and multi-clause linguistic analyses.

Data were collected by presenting video clips to participants, who provided verbal descriptions. We transcribed co-speech gestures accompanying sentences that included manner or path event descriptions. We focused exclusively on the stroke phase of the gestures, following the Özyürek and Kita (2005) approach. These gestures were termed "target-eventgestures" andwere categorizedbased onthe mannerand/or pathof theevent they conveyed,falling intothe categoriesof Manner,Path, Combined(Manner +Path), or Unclear. Manner gestures conveyed only the manner of motion, Path gestures conveyed solely thepath, andCombined gesturesconveyed bothmanner andpath concurrently.Any unclear gestures were classified as Unclear. Categorizing the target-event gestures was a collaborative process involving a native speaker consultantand anotherconsultant. Thefinal classificationswere basedon agreementbetween the experimenter and the consultants The participant'shand wentsimultaneously fromthe topright tothe bottomleft ofthe screen in this case to represent the path component of travelling from one direction to another.

Furthermore, the crawling motion of their fingers revealed the move's way. Thesegestures weresynchronous witha motionaspect intheir accompanyingspeech, but the gestures themselves were complex and unclear Therewere instanceswhere participantsmoved theirhands rhythmicallywhile describingthe manner aspect of the motion, but the gestures were not clearly indicative of manner gestures. In suchcases, thegestures weregrouped withunclear gesturesor pathgestures, dependingon the agreement between the two consultants. Our methodology primarily adopts a qualitative approach, analyzing speech-gesture alignment in Telugu narratives. We utilized software tools such as ELAN for annotation, segmentation,transcription, anddata translation.Additionally, tocraft aneffective stimulus for the research, we employed the PsychoPy software. These tools ensured rigorous data analysis, helping us gain in-depth insights into the linguistic relationship with gestures. Ouranalysis wasprimarily basedon thefrequency withwhich participantsused different syntactic categories and the frequency with which they used single versus multi-clauses. Additionally,we consideredthe frequencywith whichpeople gesturedfor themotion event during co-speech. Ourstudy unveiledintriguing findings.Telugu speakersconsistently favoredpath gestures, even beyond their verbal expressions. This observation held true despite the utilization of various syntactic categories beyond traditional path verbs. The prevalence of path gestures overmanner gesturesremained consistentamong Telugu,Turkish (aVerb-framed language), and English (a satellite-framed language) speakers, although the precise reasons for this preference remain unclear. The salience of the path component in event descriptions, as suggested byTalmy (2000),may contributeto thisphenomenon. Existingresearch indicates that individuals often focus on the endpoint or goal of an action, aligning with the natural inclination towards path information observed in infants and children. This path-centric preference appears to be a universal feature of the human representational system.

Whenconsidering clausecomplexity, Teluguspeakers predominantlyutilized path-only gestures inboth single-clauseand multi-clauseexpressions.Non-parametric testsconfirmed the significant prevalence of path gestures. This consistent dominance of path gestures challenges the assumption that multi-clause sentences would elicit more diverse gesture patterns. The saliency of the path in Telugu's linguistic characteristics contributes to this

prevalence.These resultsemphasize theimportance ofinvestigating thefactors influencing language-gesture interaction across linguistic variations.

Insummary, ourresearch shedslight onhow linguisticpeculiarities ofa languagelike Telugu deeply influence gesture patterns, offering valuable insights into the cognitive processes underlying language and gesture production. Our findings contribute to a richer understanding of the intricate connections between language, thought, and gesture, emphasizingthe needto explorelanguage-gesturerelationships indiverse linguisticcontexts.

## Role of Contingency in Reward-Emotion Interactions

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Introduction:
Although reward and emotion are closely related constructs, research in these domains has proceeded in a largely independent fashion. Recently, some studies have investigated the interactions between reward motivation and emotion (Wei & Kang, 2014). In all these studies, reward motivation was manipulated by offering participants performance-based rewards. Hence, it is currently unknown whether the effects of incentives reported in previous work were driven by the expected reward or the contingency between a successful response and reward outcome. This is important to investigate as it would clarify whether the effects of reward motivation on emotional processing reported previously were driven by the expected reward value alone or whether contingency plays a critical role in driving reward-emotion interactions. If contingency plays an important role, then the previous work on reward-emotion interactions, which primarily focused on interpreting the interactions along the common evaluative dimensions of value/valence and salience/arousal needs to incorporate the overlooked role of contingency in reward-emotion interactions. Thus, determining whether contingency moderates the influence of reward motivation on emotional processing would provide important insight into the factors that affect reward-emotion interactions, which is of both basic and clinical relevance.
To address this question, we conducted a behavioral experiment to specifically investigate the role of contingency in the interactions between reward motivation and goal-relevant emotion. Inspired by the experimental design of Shehnav and colleagues (Fromer et al., 2021), we employed a factorial manipulation wherein an initial cue provided information about the reward level (high/low) and contingency (contingent/non-contingent). During the subsequent task phase, as a goal-relevant emotional manipulation, participants performed an emotional face categorization task involving happy, neutral, and fearful expressions. Based on the differences in reward-driven arousal between contingent and noncontingent cues (Manohar et al., 2017), we hypothesized that contingency would play a crucial role in modulating reward-emotion interactions.

Methods:
The study involved 48 healthy adult participants (25 males; age M = 21.63) and was divided into two phases:
Calibration Phase: In the Calibration phase, participants performed an emotional face categorization task (Happy, Neutral, or Fearful). The face stimuli were presented for 1000 ms and participants were asked to categorize the emotional expression within a response window of 1.5 s. For each participant, at the end of the Calibration phase, the RT threshold value was calculated separately for each emotion expression condition by computing the median RT value of the accurate responses.
Main task phase: At the start of the Main task phase, participants were again instructed to perform the same emotion categorization task (as in the Calibration phase) but with the prospect of winning additional bonus rewards. The compound visual cue at the start of each trial in the Main task phase informed participants about the amount of bonus reward they could win on that trial and whether the reward outcome depended on their performance (Fig. 1A). The high or low reward level was indicated using a golden money bag (100 points) or green rupee symbol (10 points) respectively, and whether the reward would be based on their performance or not was indicated using a lightning symbol (contingent condition) or a blue circle (noncontingent condition) respectively (Fig. 1B). On contingent trials, participants won bonus points on each trial if they made a fast and accurate response.To qualify as a fast response, they should respond faster than the corresponding RT threshold of that valence condition, which was calculated previously from the Calibration phase. If the response was correct but slower than the RT threshold, participants won zero points. In contrast, during the noncontingent trials, winning a reward was not dependent on the participant's performance. Instead, the probability of winning a reward on a noncontingent trial (independent of whether the response was correct or incorrect) was calculated based on the success rate in 10 preceding contingent trials of the corresponding reward level. This was done to ensure that participants win a similar amount of bonus reward during the contingent and noncontingent conditions so that any observed differences in behavioral measures were not driven by the changes in the expected value of reward across conditions.
Overall, we used a 2 Contingency (contingent, noncontingent) x 2 Reward (high, low) × 3 Emotion (happy, neutral, fearful) within-subjects factorial design in the Main task phase. A total of 288 trials were employed (24 each of 12 different experimental conditions), which were divided into six self-balanced runs of 48 trials each.

Results:
RT data from the Main Task phase were evaluated according to a 2 Contingency x 2 Reward x 3 Emotion RM-ANOVA. We detected a three-way interaction between Contingency, Reward, and Emotion. To understand the nature of the observed three-way interaction effect, we ran two additional 2 Reward x 3 EmotionRM-ANOVA analyses separately for contingent andnoncontingent conditions. A significant Reward x Emotion interaction was observed during thecontingent condition (Fig.

2A). This two-wayinteraction during the contingent condition was primarily driven by the greater facilitation effectof high vs. low reward on fearful faces compared to neutral and happy ones. No difference was observed between the reward facilitation effects ofhappy and neutral faces. In contrast, during the noncontingent condition, a Reward x Emotion interaction was not detected (Fig. 2B). Other results of interest related to two-way interactions and main effects are reported in table below. We also conducted a 2 Contingency x 2 Reward x 3 Emotion RM-ANOVA on theaccuracy data. A similar three-way interaction pattern was also observed in the accuracy data (Table 2).

Discussion:
In the present behavioral study, we investigated the role of contingency in the interactions between reward motivation and categorization of emotional facial expressions. In terms of both RT and accuracy data, we observed a significant three-way interaction between contingency, reward, and emotion. Specifically, in the RT data, we found a significant interaction between reward and emotion in the contingent condition, with a greater facilitation effect of high (vs. low) reward during the categorization of fearful relative to neutral faces. However, we did not detect any significant interaction between reward and emotion in the noncontingent condition. A similar three-way interaction pattern was also observed in the accuracy data ruling out any speed-accuracy tradeoffs. The observed three-way interaction pattern could be interpreted by extending the arousal biased competition model framework (Mather & Sutherland, 2011) to reward-emotion contexts. In conclusion, our study demonstrated the critical role of contingency in driving the effects of reward motivation during the categorization of emotional facial expressions.

**Proactive control of emotional conflict mediated by informative cues and its interaction with temporal unpredictability**

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Introduction

The dual mechanisms of cognitive control framework (Braver, 2012) proposes that cognitive control is implemented in two distinct modes: (1) proactive control mode, where advanced preparatory control mechanisms are invoked in anticipation of the conflicting information, and (2) reactive control mode where one reacts to the conflicting information at hand without any advance preparation. Several past studies have investigated proactive control of non-emotional conflict (Soutschek et al., 2014). However, very little is known about the proactive control of emotional conflict, which involves competition between task-relevant and task-irrelevant emotional information (Etkin et al., 2006).

One of the ways in which proactive control can be invoked is by providing advance information in the form of pre-cues about the upcoming task at hand e.g., a speed bumper sign. One crucial feature of informative pre-cues triggered proactive control is the timing of their occurrence. In non-emotional conflict tasks, it has been reported that a minimum cue-to-stimulus task interval (CSI) of 2 sec is needed for informative cues to have sufficient preparation time to benefit conflict resolution (Bugg and Smallwood 2016). Another interesting aspect that has not been examined previously is the predictable vs. unpredictable temporal structure of the CSI. Based on some previous work (Koppe et al., 2014), we hypothesized that the proactive control and temporal unpredictability processes may interact with each other. Overall, the primary goal of the present behavioral study is to investigate the influence of task-informative cues on emotional conflict processing and how it interacts with the temporal structure of the CSI.

Methods

We conducted two experiments which differed only in their temporal structure of CSI- predictable (Exp. 1) and unpredictable (Exp. 2). For Exp.1, we recruited 36 healthy adult participants (20 males; 22.3 ± 2.4 years). Each trial (Fig. 1) started with the presentation of an uninformative or informative cue (1 sec) indicating the nature of the congruency of the upcoming trial during the subsequent task phase. There were two different types of informative cues (blue/yellow square) indicating the incongruent or congruent nature of the upcoming trial (100% valid; colour-congruency mapping counterbalanced across participants). The uninformative cue (grey square) was followed by congruent or incongruent trials with equal probability. Then, a central white fixation cross was shown during the fixed CSI period (3.1 sec), followed by the emotional conflict task phase, where a central facial stimulus with a fearful, happy, or neutral expression was shown with an overlaid word (1 sec). The overlaid word can be congruent or incongruent with respect to the facial expression. For instance, the word “FEAR” displayed on a fearful expression face would make it a Congruent trial, and the word “HAPPY” displayed on a fearful expression face would make it an Incongruent trial. Participants were instructed to judge the emotional expression of the face, ignoring the overlaid word (button mapping counterbalanced across participants). Finally, each trial ended with a variable inter-trial interval (2-6 sec).

For Exp. 2, we recruited a new set of 37 healthy adult participants (17 males; 24.6 ± 2.9 years) from the same community. These participants performed the same exact task as in Experiment 1, the only difference being the CSI period was variable, ranging from 2-6 sec sampled from an exponential distribution with median of 3.1 sec (see Fig. 1).

Results

We mainly examined how informative cues modulated performance on incongruent conflict trials which involves competition between task-relevant and task-irrelevant emotional information, and the role of fixed vs. variable CSI in it.

We ran a 2 x 2 mixed model ANOVA with CSI (fixed, variable) as a between-subject factor and Information (uninformative, informative) as a within-subject factor on incongruent trials reaction time (RT) data (Fig. 2A). We found a significant CSI x Information interaction ($F(1,71) = 4.36$, $p = 0.04$). This interaction was driven by faster responses after informative compared to the uninformative cues in the fixed CSI group ($t(1,35) = 2.94$, $p = 0.006$). There was no significant RT difference between the trials following informative vs uninformative cues in the variable CSI group ($t(1,36) = 0.24$, $p = 0.81$). Additionally, we found a main effect of CSI ($F(1,71) = 8.38$, $p = 0.005$), with RT in fixed CSI group being faster than the variable CSI group. Also, a main effect of Information was detected ($F(1,71) = 7.47$, $p = 0.008$), with RT being faster after informative cues than uninformative cues.

For completeness, we also ran a separate 2 x 2 mixed model ANOVA with CSI (fixed, variable) as a between-subject factor and Information (uninformative, informative) as a within-subject factor on congruent trials RT data (Fig. 2B). We found a main effect of CSI($F(1,71) = 9.94$, $p = 0.002$), with RT in fixed CSI group being faster than the variable CSI group. Also, a main effect of Information($F(1,71) = 63.51$, $p < 0.001$), with RT being faster after informative cues than uninformative cues. However, CSI x Information interaction was not detected ($F(1,71) = 0.72$, $p = 0.39$).

Discussion

The RT data of two experiments provided important insights regarding the influence of informative cues on emotional conflict processing. The rmANOVA results indicate that task-informative cues were able to help reduce the emotional conflict on incongruent trials only when the timing of the task stimulus onset is predictable. On the other hand, during congruent trials where participants could simply switch their strategy to reading the word label to provide a correct response, informative cues aided performance independent of whether the task stimulus onset was predictable or not. Overall, our findings demonstrated that proactive control triggered by task-informative cues can help reduce the emotional conflict under specific conditions.

**Structural Brain Correlates of Co-morbid Depression in Autism Spectrum Disorder**

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Introduction

Autism Spectrum Disorder (ASD) involves diverse neurodevelopmental syndromes with significant deficits in communication, motor behaviours, emotional and social comprehension. Additionally, individuals with ASD often exhibit comorbid conditions, one of them being depression1. Depression is characterised by a persistent change in mood and diminished interest in previously-enjoyable activities. Although the current literature on depression in adults with ASD is limited, unique traits emerge due to depression, i.e., suicidal thoughts and negative self-concept2. Due to communicative challenges and lack of appropriate assessments, it can often go undiagnosed during routine clinical examinations and especially so in adults due to emergence of camouflaging behaviours. Therefore, understanding the neural basis of the comorbid psychopathology of depression in ASD is relevant for identifying potential markers and targets for its management. Our study, employing structural MRI and phenotypic data from the Autism Brain Imaging Data Exchange II (ABIDE II) repository, addressed this goal.

Objectives

1. Examine the relationship of regional gray matter volume (rGMV) with comorbid depression and autism severity within regions of a priori interest (ROIs) specifically, in adults with ASD.
2. Examine the voxel-wise rGMV differences of the whole brain between ASD and typically developed (TD) adults

Method:

We sourced T1-weighted sMRI and phenotypic data from the ABIDE II repository3. Documented Autism Diagnostic Observation Schedule (ADOS) scores were used as a measure of the clinical severity of ASD for the participants. Additionally, Beck's Depression Inventory (BDI) scores were used to establish the presence and severity of depressive symptoms. A final sample size of 44 ASD participants (mean ± SD: age = 21.23 ± 3.17 years, ADOS = 9.77 ± 2.83, BDI = 9.51 ± 9.55; 4 females) and 39 TD participants (mean ± SD: age = 22.36 ± 3.26 years; BDI =5.89 ± 4.23; 9 females) was reached. Overall, the gender ratio of the ASD cohort (males:females) was 10:1, while that of TD cohort was 10:3.

Anatomical brain ROIs were defined by the WFU PickAtlas Toolbox on MATLAB 2022a. We focused on the following ROIs which were earlier implicated in both depression and ASD4: the medial prefrontal cortex (MPFC), amygdala, thalamus, anterior cingulate cortex (ACC), inferior occipital cortex, superior temporal sulcus, the Rolandic operculum, and the cerebellum. Imaging data were processed and analyzed using a combination of Statistical Parametric Mapping 12(v7771) + Computational Anatomy Toolbox v12.8.1 (r2043)5 hosted on MATLAB 2022a.. The relationship of rGMV with comorbid depression and autism severity in individuals with ASD within ROIs was ascertained using multiple linear regression. The comparison of rGMV differences between the ASD and the TD samples as conducted using an independent sample t-test, after ensuring the normality with Shapiro-Wilk's test for normality. Too avoid any potential confounds, the total intracranial volume (TIV), age and the scanning site locations were always controlled for as default nuisance covariates unless otherwise mentioned. However, due to non-availability of the medication information of participants in the database, this potential confound was not factored into the analyses. . For all purposes a threshold of $p < 0.05$ was considered statistically significant.

Results:

First, multiple regression was performed between the rGMV of a few a priori ROIs in the ASD sample. Using Pearson's correlation, we found a negative correlation in the right thalamus between the rGMV and the BDI scores (x = 18, y = -22, z = 14; Bonferroni corrected pFWE = 0.025; kE = 49 voxels). Next, we split the data by the median ADOS score (10), into high ADOS (> 10; 12.75 ± 1.94.) and low ADOS (≤ 10; 8.07 ± 1.53) sub-samples, when analyzing the interaction between the clinical severity of ASD symptoms (ADOS scores) and BDI scores in predicting the rGMV. This revealed a significant interaction in the left Cerebellum Crus 2 (x = -15, y = -84, z = -39; Bonferroni corrected pFWE= 0.0019; kE = 66 voxels), such that in individuals lower on the ASD spectrum (low ADOS), increased comorbid depression correlated with decreased rGMV, while the opposite trend appeared for those higher on the spectrum (high ADOS). Lastly, we found a significant decrease in the rGMV of the left medial superior frontal gyrus in ASD vs. TD (x = -10, y = 30, z = 42; uncorrected $p < 0.001$, extent threshold = 116 voxels; kE = 30), in a whole brain exploratory comparison while controlling for BDI. Repeating the earlier analysis by factoring in BDI, a significant alteration in the rGMV of the left superior parietal gyrus was discovered in ASD (x = -20, y = -57, z = 60; uncorrected $p < 0.001$; extent threshold = 95).

Discussion

The present study aimed to investigate the differences in rGMV in ASD and whether these differences, if any, are correlated with the severity of comorbid depression. Amongst the results which survived stringent statistical corrections, we identified a significant decrease in the rGMV of the right thalamus with proportionate increase in the clinical severity of the ASD symptomatology. Furthermore, the left cerebellum crus II demonstrated a significant interaction between the clinical severity of ASD and of depression reflecting mutually opposite ways by which the severity of comorbid depression influences the two subsets of individuals with ASD who are relatively lower and higher on the spectrum respectively.

The role of the thalamus has been extensively studied in individuals with ASD such as in sensory abnormalities and emotional processing. In the context of the present study, the thalamus is responsible for several higher cognitive and social functions, especially around the self, which are associated with increased susceptibility to depressive symptoms in ASD adults6. Similarly, the cerebellum is also known to play a role in important affective and mentalizing functions in individuals with ASD7. This region's connectivity has implications for depressive symptoms, especially due to its role in affective processes, particularly the theory of mind, facial recognition, and emotional comprehension; all crucial in both ASD and depression.

The above trend underscores the relevance of structural brain features in relation to higher cognitive dysfunctions in ASD. These findings offer valuable insights to enhance our understanding of existing complex relationship between brain-based measures and cognitive-behavioural manifestations, particularly in the context of comorbid depression among adults with ASD, thus contributing to improved insights for interventions and management of ASD.

**Preventing the return of fear memories with pleasant music in humans**

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Introduction

A single cue of conditioned stimuli triggers the stored fear memory in humans. This reactivated fear memory is transiently labile and is susceptible to modifications. The procedure of memory update upon single trial reactivation is known as memory reconsolidation (Nader, 2015). Nevertheless, fear memory reconsolidation is critical and has been ill-defined. Although ample literature is available on memory reconsolidation mechanisms, the prevention of fear of memory return is limited. Several intervention methods were used to modify or inhibit fear memory, such as pharmacological, neurostimulation, cognitive behavioural therapy, and exposure therapy. However, significant research supports the failure to target memory reconsolidation (Stemerding et al., 2023; Golkar et al., 2012; Kindt and Soeter, 2013; Wood et al., 2015). Hence, the irregularity in the memory reconsolidation reactivation paradigm has encouraged researchers to investigate some novel interventional methods to target memory reconsolidation. In the current study, authors were motivated to use pleasant music as an intervention technique. Based on the available music literature, one can assume the efficacy of music in memory reconsolidation upon reactivation. It is known that post-treatment memory may get enhanced, suppressed, or remain intact. We hypothesize that music may improve the process of memory reconsolidation. Hence, we propose using pleasant music (e.g., nature's music) to prevent the return of fear memory.

Methods

We investigated the hypothesis that the influence of music played during the memory reconsolidation window (i.e. after memory reactivation followed by a 10-minute break) blocks the fear return. A well-established auditory fear conditioning paradigm was implemented (Asthana et al., 2015). The experimental study was a three consecutive day (20-26 hrs time gap). All 60 participants were randomly assigned into three groups: (i) control group, Standard Extinction (SE), (ii) Reactivation-Extinction (RE) group and (iii) Music Reactivation-Extinction (MRE) group. The auditory fear conditioning paradigm was subdivided into five phases (day 1: habituation and acquisition; day 2: extinction; day 3: reinstatement of the fear response and re-extinction). In the habituation phase, participants were only exposed to the stimulus (CS-, CS+). In the acquisition phase, they acquire fear by repeatedly pairing CS+ with the unconditioned stimulus (UCS: woman screaming sound from the International Auditory Database System(IADS)) with 100 % reinforcement. On day 2, the RE group participants underwent reactivation of fear memory followed by a 10-minute break and extinction training. The MRE group underwent reactivation of fear memory followed by music and extinction training. In contrast, the control group (SE) underwent only extinction training. On day 3, all three groups were exposed to four un-signalled presentations of UCS to reactivate previously learned fear responses. The conditioned fear response was calculated by comparing the skin conductance response of conditioned and unconditioned stimuli.

Results

A repeated measures ANOVA with phase (habituation, acquisition and extinction) as the within-subject factor and intervention groups (SE, RE, and MRE) as the within-group factor indicated that there was a significant main effect of phase (habituation and acquisition) across all participants [$F (1, 46) = 211.243$, $p<0.001$, $\eta p2= 0.821$]. The result suggests that all three groups had similar fear responses during the habituation and acquisition phases. Moreover, a significant main effect of phase (acquisition, extinction) on the SCR responses [$F (1, 46) = 100.085$, $p< 0.001$, $\eta p2= 0.685$]. A significant interaction effect between phase (acquisition, extinction) and groups [$F (2, 46) = 4.653$, $p= 0.014$, $\eta p2= 0.168$]. Our results highlight non-significant differences in the SCR responses between the extinction and re-extinction phases [$F (1, 46) = 0.659$, $p= 0.421$, $\eta p2= 0.014$]. Further statistical analysis revealed that the difference in SCR between Group 1 (SE) and Group 2 (RE) was statistically significant, $p =.00$, level. There was also a substantial difference in SCR between Group 1 (SE) and Group 3 (MRE) at the $p =.00$ level. However, there was no significant difference in SCR between Group 3 (MRE) and Group 2 (RE) $p =.95$. Results indicate that the MRE group was more effective in reducing fear response than the RE and SE groups in the reinstatement of fear phase. Furthermore, there was no significant difference observed between SE and RE groups.

Discussion

The current study is the first to report the efficacy of music intervention in preventing the return of fear in humans. It might offer a drug-free paradigm for war veterans, patients with post-traumatic stress disorder, and individuals with specific phobias. Our results show that music, along with extinction training during the reconsolidation window, is effective in dousing the fear response. Like previous findings, the current study also reports a drug-free paradigm. Thus, it could be utilized as an intervention technique (drug-free paradigm) for war veterans, patients with post-traumatic stress disorder, and individuals with specific phobias.

Keywords: reactivation-extinction; fear memory; music, reinstatement, SCR

**A non-linear EEG correlation study on timbral cognition of Instrumental Hindustani Classical Music**

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Music of any form is a time series variation of different note combinations, where each note has a particular frequency. Neural responses from different parts of brain are recorded with the help of EEG experiment. These responses are interpreted in forms of non-linear, non-stationary time series. Since music and brain signals, both are complex time series, it would be interesting to study whether any kind of correlation exists between these two series or not. Using the techniques of 'Sonification' and 'Multifractal Detrended Cross Correlation Analysis' (MFDXA), we have tried to compute the cross-correlation coefficients (γx) between these two complex time signals. Two Indian instruments, Sitar and Flute, belonging to string and wind family of instruments respectively, were chosen and certain Alaap sections from live performances of experts were selected to prepare the clips to be used for the experiment. From audience response survey, the emotion contents of the prepared clips were marked. Finally, using happy and sad clips of these two instruments as the input signals, EEG was performed on 2 musicians (M) and 2 non-musicians (NM). The cross-correlation coefficient values between audio inputs and extracted EEG responses, as well as the coefficient values between EEG responses of different lobe-pairs were computed. Finally, the comparative values of cross-correlation coefficients for different timbres and different audience categories were studied in details. The goal of this pilot study is to develop a novel approach to classify and characterize timbres (Sitar-Flute) and audience categories (M-NM) depending upon the nature of both audio-EEG cross correlation as well as inter-lobe EEG cross-correlation.

# Effect of Valence & Uncertainty on Probabilistic Reinforcement Learning

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Introduction

The outcomesalience ofan animal'saction isknown todrive theirmotivation forlearn- ing (Bindra, 1978; Rescorla, 1988).Outcome or incentive salience (Berridge 2023) can beunderstood as a source of both hedonic valence (pleasure-displeasure) and arousal (sleepy-activated) and is, as such, akin to emotional stimuli (Russell, 2003) that have been previouslyreported to impact decision-making, especially under conditions of uncertainty (Lagisz et al.,2020, Paulus and Angela, 2012,Anderson et al., 2019, Morriss et al., 2022). In this study, we used a probabilistic learning task and the Reinforcement Learning Drift-Diffusion Model(RL-DDM)(Pedersen et al, 2017; Fengler et al, 2022) to examine the role of outcome valence anduncertainty onlearning anddecision-making.

Methods

We used a modified version of the standard cue association learning task to investigate how outcome valence affects learning & decision-making. However, unlike previous research that used valenced feedback to indicate correct or incorrect response,we attempted to test the roleof explicitly presented valence (a pleasant or unpleasant image correctly associated with thecue andcontrolled forarousal) influencedlearning independentof theaccuracy ormonetary reward associated with it. Participants learnt to associate two Japanese alphabets (randomlyselected withoutreplacement fromthe set{u,i, tsu,chi, wa,shi, ta,so, ho,ku, nu,hi, ma,ke, ko, he, te, se, ru, yo}) to either positive or negative valence in each block. Each trialbegan with a fixation, followed by presentation of one of the alphabets at the center of thescreen. Then, two targets, a triangle and a square, were presented on either side of the cuerandomly across trials. Participants were asked to choose the square if they thought the given cue was associated with something pleasant or select the triangle if they thought the given cue was associated with something unpleasant.After participants made the choice,they were shown what the cue was actually associated with: in the mixed valence session, this was a pleasant or unpleasant image associated with that cue and in the no valence/ symbolic session, this was just the correctly associated symbol - square or triangle - with no explicitvalence associatedwith it.

1. Each session consisted of 5 blocks with 20 trials each ( 30mins). Correct outcome image associated with the cue was presented 70 percent of the times in each block.To test the specific and independent impact of positive vs.negative outcome valence on learning, datawas alsocollected fromthe sameparticipants (n= 40)on aseparate dayfor sessionsin whichthe outcome images were either positive or neutral (positive sessions) and either negative orneutral (negative sessions). The order of the four sessions (mixed valence, symbolic, positiveand negative)across thetwo dayswere counterbalancedacross participants.To testthe roleof uncertaintyin feedbackon learning,we alsocollected datafrom anindependent setof participantsfor boththe mixedvalence andsymbolic sessionswhen theprobability ofpresenting thecorrectly associatedoutcome imagein ablock was60% and80% (n= 40 each).After excluding participants based on exclusion criteria (i.e.choosing the same responsetarget, targeton thesame sideof thescreen, lessthan chance(50%) performancein last learning block, 100% accuracy, or < 200ms reaction time) data from 30 participantswas usedfor furtheranalysis.

Results

Comparing across 70% sessions with mixed valence, symbolic, positive and negative outcome imagesusing mixedlinear regressionmodel, wefound (Figure3) a)less accuracyoverall forall valenced sessions, compared to symbolic sessions b) greater accuracy for cues associatedwith unpleasant vs.pleasant outcome c) more accuracy as trials progressed in a session indicativeof learningin thetask.

RL-DDMResults: We found a significant difference in the prior bias parameter of RLDDM only in the mixed valencevs. symbolicblock (p= 0.01),not inthe others(positive -p =0.026, negative- p
= 0.477,symbolic -p =0.371). Thissuggests theeffect isdriven bythe combinedpresence of both of positive and negative valences, not by one valence alone.To explore the role ofexpected uncertainty in prior bias , we repeated the mixed valence and symbolic blocks withdifferent feedback probabilities (lower and higher than 70%). As can be seen in Figure 3, theRL-DDM prior bias parameter showed a credible difference only for the 70% correct feedbackblock (p = 0.01), not for other uncertainty levels (60% - p = 0.229, 80% - p = 0.140). Thiscontradicts ourexpectation ofa linearrelationship betweenuncertainty andbias. Interestingly, an intermediate uncertainty level exhibited bias. The increased bias in the 60% feedback probability block with symbolic feedback was unexpected.We tested if the order of performing the symbolic vs. valence blocks had anything to do in producing this effect.We found this to be the case; the prior bias parameter showed a strong difference between positive and negative conditions only in the 60% correct feedback symbolic block when it followed the valence block (p = 0), but not vice versa. Additionally, the drift rate wassignificantly lowin thecontrol blockwith 60%correct feedback.

Discussion

In our study, we aimed to explore the interaction between valence and uncertainty in aprobabilistic learning task. .We chose the RL-DDM model to account for any valence basedbias inlearning thatcould notbe explainedby learningrate alone.While wefound anincrease in prior bias as the uncertainty levels increased from 80% to 70% probabilistic feedback, a similarincrease wasnot observedin the60% vs.70% comparison,suggesting thatperhaps therelationship between uncertainty and prior bias is not a strictly linear one. It is also possiblethat 60% condition was too difficult for participants to deduce any statistical regularitiesbetween cueand outcome,for anyeffect ofvalence tosurface. Weplan toanalyze any differences inresponse strategies(e.g. win-stayor lose-switch)across levelsof uncertaintyto test this further. For further fine-tuning the analysis, we will be using a nested contrastmodel thatwould explicitlycode foruncertainty effectusing Stan.

**Audience and Brain responses to Indian Spiritual Music: A Study with Sikh Gurbani and Bangla Kirtan traditions**

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Introduction:

In India, since Vedic times, devotion and music have been intrinsically linked and remained so through centuries of foreign influences. In the context of Bhakti tradition, a pan-Indian movement, which emerged between 7th and 15th Century CE, and integrated poetry and music in the transmission of its spiritual and social goals, several devotional music traditions appeared as separate genres. These Bhakti sangeet or devotional music traditions generally grew upon the three pillars of the Indian classical music – Rāga (melodic pattern), Tāl (rhythmic cycle) and Kāvya (lyrics) – in this case expressing love, wonder, longing, awe and devotion for the respective deity or Guru [1]. Perception of emotions like awe, wonder, longing, despair, devotion and bliss are often reported by the devotees while listening to or participating in spiritual music of their own religions and cultures. Although, a few earlier studies report the effects of spiritual music on human mind and brain [2-8], most of them have worked with specific Western spiritual music traditions, and observed their effect on clinical population, while such scientific studies in the context of Indian spiritual music traditions are inadequate. This paper aims to address this gap by studying the neuro-cognitive responses as well as audience emotion responses in two such spiritual music traditions of India – (a) Gurbani and Sabad Kirtan of Sikh tradition, (b) Bangla Kirtan of Vaishnav tradition, both of which are strongly influenced by Bhakti traditions.

Methods:

For the study of audience response, multiple 30-second long music clips were taken from 6 songs of these two spiritual music traditions and 6 songs of non-spiritual genres from the same two cultures. After listening to each of these song clips, 348 participants of various age groups, gender, and linguistic backgrounds were asked to identify their perceived emotions from a set of 13 pre-decided “emotion-words” (viz., happy, sad, devotion, awe, calm etc.) and rate their corresponding intensities in a 5-point Likert scale. The emotion responses were analysed based on the percentages of respondents who marked a particular emotion for a particular clip and finally, the weighted average of the emotion intensity ratings, were compared genre-wise.

For the brain responses study, two groups of (five Punjabi and five Bengali speaking) participants listened to two 5-minute long song clips from these two spiritual music traditions while EEG signals were recorded following AB-BA design for each participant, and their emotion responses and mood states (using PANAS and BMIS) were documented before and after listening to each clip. The noise cleaned EEG signals were analysed using nonlinear MFDFA technique and multifractal spectral width (W) values were calculated for multiple 30-second EEG segments across the total duration of each music clip. Also, the changes in alpha and theta power were calculated and compared for various experimental conditions.

Results:

Results of audience response survey revealed the dominance of emotion ‘devotion’ while listening to music clips of both traditions, with a significant co-elicitation of ‘happiness’ in Bangla Kirtans and more prominent co-elicitations of ‘awe’ and ‘calmness’ for Sabad Kirtans. Average emotion arousal in female was higher than for male participants except where ‘devotion’ was the prominent response and comprehending the lyrics of the songs contributed to higher intensity of devotion perception.

Results of EEG analysis revealed that resembling the findings of Popovych et al. [3] and others [6-8], alpha and theta power increased from normal resting condition for all participants during listening to both Sabad kirtan and Bangla kirtan. Nonlinear analysis also revealed enhanced spectral complexity (empirically measured by W) in alpha frequency band for the chosen frontal, occipital and temporal electrodes while listening to the spiritual songs from both traditions.

Discussion:

This is a pilot scientific study on the perceptual and neuro-cognitive attributes of two Indian spiritual music traditions and the unique findings are expected to open new pathways for future research regarding their applicational aspects. The findings from audience response indicated the presence of different emotion subsets for the two traditions as well as gender, age group and lyrical comprehension-based differences in the perceived emotions. Further, this empirical study on the temporal changes in brain responses along with audience emotion responses collected during listening to these spiritual songs helps us to understand the perception and induction process of emotions like devotion and happiness in human brain, which is a novel step in the domain of music cognition and signal processing.

**That's Gross: Disgust Sensitivity Predicts Weight Bias in an Indian Population.**

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Introduction

Obesity is a complex and chronic medical condition characterized by excess body fat that can lead to a range of health problems. Although the rate of obesity has been on the rise globally, there is still a lot of stigma and bias towards people who are obese. Past literature suggests that people with obesity may also feel stigmatized about their weight by individuals who hold negative weight-based stereotypes, known as weight stigma, and these stereotypes may influence an individual's behavior toward a person living with obesity, known as weight bias (Lawrence et al., 2021). Prior research has examined the link between disgust sensitivity and weight bias (Lieberman et al., 2012; O'Brien et al., 2013; Vartanian, 2010; Vartanian et al., 2015). Disgust is a basic emotion triggered by unpleasant or threatening stimuli (Chapman & Anderson, 2013). It evolved to promote disease-avoidant behaviors by helping us recognize infection-related objects and situations, encouraging hygiene practices and reducing pathogen contact (Curtis, 2011). This emotion can be leveraged to encourage health-related behaviors and distance from entities seen as unhealthy or potential disease carriers. Individuals with a high concern for pathogen transmission often exhibit more negative attitudes toward obese individuals, especially when visual cues of obesity are present, suggesting that these evolved pathogen-avoidance mechanisms may drive aversion due to the perceived health risks associated with obesity (Park et al., 2007). Although research has explored the relationship between disgust sensitivity and weight bias, no studies have investigated this relationship within an Indian context. Therefore, this study aims to ascertain whether a relationship exists between disgust sensitivity and weight bias, and whether disgust sensitivity can predict weight bias in an Indian population. The study's hypotheses are as follows, H1: A significant correlation exists between disgust sensitivity and weight bias and H2: Disgust sensitivity is a significant predictor of weight bias in an Indian population.

Methods

The study consisted of a sample of 30 participants aged 18-25, inclusive, who were fluent in English, resided in Bangalore, and did not have a history of mental health disorders.. Disgust sensitivity was assessed using the 25-item Disgust Scale-Revised (DS-R), developed by Haidt, McCauley, and Rozin (1994), while weight bias was measured through a modified Implicit Association Test (IAT) based on Meade (2009). Participants completed an online Google form containing socio-demographic questions, followed by the DS-R questionnaire. Subsequently, they engaged in an offline IAT task. To address H1, a correlational analysis was conducted, and for H2, a linear regression analysis was performed.

Results

The present study explored the interplay between disgust sensitivity and weight bias in a sample of 30 participants. Descriptive statistics revealed that the group had a mean age of 22 years (SD = 1.75). Disgust sensitivity, on average, fell within the moderate range (M = 53.43, SD = 12.615), with considerable variance in the sample. The Weight IAT scores indicated a slight preference for thin people over fat people (M = 0.22, SD = 0.378). A Shapiro-Wilk test confirmed the normal distribution of all variable scores ($p > 0.05$), allowing for the use of parametric tests. However, no significant relationship was observed between disgust sensitivity and weight bias in the group ($r = 0.76$, $p > 0.05$), contrary to the initial hypothesis (H1), challenging the notion that heightened disgust sensitivity automatically translates into stronger weight bias in an Indian Population. In this study, we tested the hypothesis (H2) that disgust sensitivity is a significant predictor of weight bias in an Indian population. However, as previously discussed, our findings did not reveal a significant correlation between disgust sensitivity and weight bias. This absence of a significant relationship between the two variables precluded the possibility of performing a regression analysis to test H2.

Discussion

The results of this study challenge prior research suggesting a straightforward connection between disgust sensitivity and weight bias (Lieberman et al., 2012; O'Brien et al., 2013; Vartanian, 2010). Our findings indicate that this relationship may be more intricate than previously assumed, as no significant correlation was observed between disgust sensitivity and weight bias in our sample. The results suggest that other factors may come into play, potentially moderating the influence of disgust sensitivity on weight bias. Factors like socio-cultural context, individual differences, or specific life experiences may contribute to this complexity. Moreover, the absence of a significant relationship between disgust sensitivity and weight bias raises questions about the role of cultural context, particularly in diverse settings like India. Research by Skolnick and Dzokoto (2014) has already highlighted substantial cultural variations in disgust sensitivity and emphasized the role of high disease risk prevalence in shaping these differences.

Our study has some limitations. We primarily focused on a single measure of disgust sensitivity without considering other potential moderating factors. A more comprehensive assessment of disgust sensitivity, including its specific dimensions, could yield a deeper understanding of its link to weight bias. Furthermore, our relatively small sample size may have limited

our ability to detect significant correlations. Future research should aim for larger and more diverse samples to provide more robust insights. Investigating the underlying factors that moderate the relationship between disgust sensitivity and weight bias is crucial. Additionally, exploring how interventions and educational programs might influence this relationship could be a valuable avenue for future research, potentially contributing to the reduction of weight stigma and the promotion of more inclusive attitudes.

**Thalamic interactions in emotional arousalInsights into Aperiodic and Periodic EEG components**

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Introduction:
EEG spectral signals contain both periodic and aperiodic (exponent, offset) components, segregating which is relevant for determining the underlying mechanism. Emotion literature has rich works in periodic findings while aperiodic or 1/f component is less explored. Therefore this study sought to determine whether seeing emotional music video clips has an impact on aperiodic components. To elucidate the underlying mechanisms, we employed a thalamo-cortical model, which provides insights into the plausible explanations for our empirical observations.

Methods:
Dataset: In our study, we employed EEG recordings with 32 channels and a sampling rate of 512 Hz from the Open Source Affective Database for Emotion Analysis using Physiological Signals. The dataset included 32 participants evenly distributed by gender, with an average age of 26.9 years. During the sessions, each participant viewed 40 different 60-second music videos with fixed 5-second inter-trial intervals. After each video, a 3-second fixation period preceded participants' emotional ratings using 1-9 Likert scales for valence and arousal.
Preprocessing and Spectral Analysis: To prepare the data, we applied a systematic approach, which included bandpass filtering (1-45 Hz), removal of bad channels, and Independent Component Analysis (ICA) for artifact removal. Data was re-referenced to the common average. We then conducted multitaper analysis followed by application of Fitting Oscillations and One Over F (FOOOF) method on the mean power spectrum of the 60-second trials across all electrodes. We then categorized the spectral parameters of trials into high and low arousal and valence groups based on participant ratings, using a threshold of 5[3]. Model Simulation: To investigate the underlying mechanisms driving changes in EEG activity's periodic and aperiodic characteristics in response to emotional stimuli, we developed a thalamocortical model. This model integrated key parameters, including time constants and coupling strengths[4]. We validated the model by comparing its simulated data with empirical EEG recordings under various emotional arousal conditions. In our model, we introduced emotional arousal states by manipulating the negative mean inputs to the relay population. In each simulation run, we applied the FOOOF algorithm with the same parameters as in EEG analysis to extract peak alpha power and the characteristics of the background activity under different mean inputs.

Results:
We examined how arousal and valence impacted the exponent (-1× slope) and offset values in our study. To assess the statistical significance of these effects, we conducted permutation tests by comparing trials categorized as having high or low arousal and valence states. Our results indicate a significant rise in the average exponent value as arousal levels increase ($p = 0.0022$) and a significant increase in offset ($p < 0.001$). Additionally, we observed a noteworthy decrease in the average peak alpha (8-12 Hz) power as arousal increased ($p = 0.0434$). Conversely, the average exponent value displayed a non-significant decrease with changes in valence ($p = 0.1884$), as did the offset ($p = 0.2274$), and average alpha peak power ($p = 0.9694$). To replicate neural responses associated with emotional arousal states, we applied the thalamocortical model with varying negative mean inputs to the relay population, creating a gradient of emotional arousal states. Our observations indicate that stimulus presentation leads to a reduction in alpha power, a steepening of the 1/f slope, and an increase in the offset, mirroring what is observed empirically.

Discussion:
Our investigation offers insights into how emotional states, particularly arousal, influence aperiodic components in EEG signals. We noted a significant increase in both the aperiodic exponent and offset when participants were exposed to video clips associated with high arousal levels, as opposed to those inducing low arousal. This significant contrast suggests the presence of active inhibition mechanisms [1] in high arousal states, deepening our understanding of emotional processing. Remarkably, our analysis did not reveal substantial differences in aperiodic components when comparing high and low valence classifications, indicating that valence may have a more nuanced impact on these EEG characteristics, warranting further exploration. Additionally, the reduction in peak alpha power during high arousal conditions, as opposed to low arousal conditions, aligns with previous research linking alpha power to emotional arousal. To delve into the mechanistic underpinnings of these rhythmic and arrhythmic elements, we employed a thalamo-cortical model. Our findings suggest that the negative mean input to the thalamic relay population may be attributed to enhanced coupling between thalamic reticular and relay nuclei within this model, especially in response to variations in emotional arousal states,indicating a dominance of inhibition over excitation at the thalamic level.

Limitations: It's important to note that the dataset paradigm design involved post-video rating, which limited the model's input to a single value of arousal per trial without temporal resolution. Furthermore, our model treats the entire cortex as a single E-I population, precluding the derivation of spatial distribution effects.

**Characterizing the Transitions in Emotions while Listening to Naturalistic Music Stimulus**

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Introduction:
Emotions are intricately linked with our actions and influences most of our higher-order cognition like attention, decision-making and memory. Variable emotional perception can lead to the variability in all these processes. Although the field of emotion has seen great progress over several decades, our understanding on the variability of emotional experiences remains sparse. Our primary objective in this study is to capture individual variability in emotion dynamics using a naturalistic music stimulus. Conventionally, music and movies have been known to evoke intense emotional experiences which are observed as similarly shared responses at both behavioral and neural level. However, in this study, since our aim was to capture interindividual differences in emotional experiences, we leveraged the potential of classical music known to have the potential to elicit multitude of emotions from a single piece. We constructed our stimulus from 8 different ragas of varying valence. The choice of these ragas is based on previous research, which elucidated their effect in eliciting distinct emotional responses[1]. Participants were instructed to continuously rate the stimulus on a two-dimensional scale of valence and arousal while listening to the music inside the scanner. By collecting continuous emotional responses to the musical stimulus, this study enabled us to dynamically characterize the variability in emotional responses, much like the real-life experiences[2–4]. Variability in emotion perception has been investigated under the regime of healthy aging but remains a relatively unexplored field in normal adults. This study can facilitate us to gain a deeper explanatory insight on whether the behavioral variability in emotion perception while listening to music can be mapped to distinct neural underpinnings.

Methods:
The stimulus was created by concatenating 8 different classical ragas of varying length (30s – 105s), into a continuous piece of 513 seconds. The chosen compositions were performed using a sarod, accompanied by tabla[5]. While sourced from different ragas, all segments were derived from the 'gat' section of their respective ragas, ensuring a consistent tempo. This approach aimed to counter critiques regarding the influence of tempo on emotional response.
Participants (N = 23; Mean age = 26; Male : 9 , Female : 14 ) were presented with a circular scale of emotions derived from Russell's circumplex model of affect[6] (Fig 1) inside the fMRI scanner. Using a joystick, visible on the screen in front of them, participants had to continuously rate the music by moving the pointer to the suitable quadrant or location that represented their emotional response. Stimulus presentation and cursor position recording were performed using the Presentation software by Neurobehavioral Systems. The cursor's position was captured and recorded at a frequency equivalent to the screen's refresh rate, which typically operated at around 60 Hz. Both valence and arousal time series were normalized and downsampled (step size=1s) for further analysis. Prior to the main study, additional pilot experiments (behaviour only) were conducted (N = 12; Mean age = 27; Male: 3, Female: 9), where participants were asked to listen to individual pieces after each of which they had to provide discrete ratings on a scale of 1-7 for both valence and arousal. The sequence of the stimulus was randomized for 2 groups (N=6 each). The current study is focused on the behavioural results of the main and pilot experiments, which mainly involves subjective ratings and intersubject analyses.

Results:
Upon analysing the mean ratings of valence and arousal, our findings revealed an emotionally dynamic experience. The fluctuations observed in arousal suggest a dynamic emotional response. Likewise, the valence trajectory reflects the richness of the stimuli, encompassing segments of music that evoke both positive, negative, and neutral affect (Fig2 a). However, both dimensions indicate a high variability of ratings. Visualizing the heatmap of ratings from all participants provides further insights, demonstrating that the density of responses is not concentrated in any specific location or quadrant but rather spread across the entire spectrum (Fig 2b). This dispersion also mirrors the high variance in emotional responses among the participants. We next sought to ask whether the valence and the arousal show equally varied responses. For this we performed a leave-one-out intersubject correlation (ISC) on the valence (r=0.44) and arousal (r=0.19) (Fig3). This shows that although individuals are perceiving the valence relatively similarly, they still show variable emotional experience (intensity of experience). Thus, valence cannot be attributed solely as the cause of this variability. We then wanted to see whether the variability fluctuated across the entire stimulus. For this, we plotted the variance at each time point and plotted it as a time series across the length of the stimulus. We observe that the variance indeed continuously fluctuates with time which was captured by the continuous rating (Fig4). We next explored whether this variability is driven by one or few segments of the stimulus. For this we calculated segment-wise variance of the ratings, which revealed a similar pattern of high variability across all segments (Fig5). To further address the question of whether the sequence of the music pieces was driving this variability, we compared the variance of each segment for both dimensions between the continuous and discrete group (Fig5). Interestingly, the discrete group exhibited a more or less similar pattern of variance for all segments, barring the initial one. This finding strongly suggests that the sequence of the music pieces might not be the primary reason for the observed variability in emotional responses.

Discussion:

The results highlighted the dynamic and multifaceted nature of the emotional experience during music listening. Furthermore, the variability in emotional responses was not attributed to the sequence of the music, as demonstrated by high variance in both continuous and discrete ratings for different music segments.

Traditionally, previous research has predominantly focused on exploring shared emotional responses to music and identifying specific physical attributes of music that elicit certain categories of emotional reactions. Some studies have also delved into the influence of cultural backgrounds and personality traits on individuals' perceptions of emotional content in music[7].

This study's focus is, however, on the individual differences in emotional perception at neural level. In future, we will investigate the neural underpinnings that are associated with this intricate variability across participants, particularly among participants with similar cultural backgrounds, while maintaining consistent physical attributes such as timbre and tempo in the music stimulus.

**Impact of emotion words on affect perception**

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The Bayesian model of the brain relies heavily on reducing the prediction error and constantly updating the generative model with every sensory input (Knill & Pouget, 2004). Put into this Bayesian model, emotions are termed as constructive (Barrett, 2017). The attempt to elucidate the relationship between language and emotion perception now becomes critical with the possibility of language having a top-down influence on emotion perception. Lindquist et al. (2006) carried out a perceptual matching task following semantic satiation. Participants were less accurate in matching an emotional face they had seen earlier after satiation of an emotion word. Gendron et al.(2012) tested their "Language-as-a-prior"hypothesis where according to theory of constructed emotion, labels should influence how emotion instances are being constructed. Reduced perceptual priming effects were found after the semantic satiation of the emotion word. Thus according to the authors, emotion percepts encoded before and after the semantic satiation effect disappeared were different (Gendron et al.,2012). The question that all the studies point towards is the determination of the stage where labels have an effect on emotion perception. The current study tries to address the question by combining an emotion-induced-blindness paradigm (EIB) with semantic satiation paradigm.When an emotional distractor image is presented just before the target , there is impairment in the target detection. The accuracy increases as the relative position of the target from the distractor increases (Wang et al., 2012). Semantic satiation paradigm paired with EIB paradigm would allow the manipulation of inaccessibility to conceptual knowledge through emotion words and see its effect on target detection accuracy in participants. The experiment had 256 trials. The experiment was divided into two blocks of 128 trials. The division of blocks was based on if the word is repeated before the RSVP task. The order of blocks were randomized. At the start of the trial, a fixation cross was presented for 1000 ms. Following the fixation cross, the word was presented on the screen according to the number of repetitions. There were a total eight words: Four words belonging to the emotion category (Happy, sad, fear, angry) and four belonging to the control word category (virtue, mastery, sequence, oblique). The control words were chosen from (Hill,1985) based on the criterion of concreteness, context,availability and imageability. Following the word presentation, 22 images were presented with images presented on screen for 100 ms. In every trial, there was a target image embedded in the RSVP image stream. The target image was characterized as tilted to either right or left side by ninety degrees. The emotional distractor image taken from the International Affective Picture System (IAPS) (Lang et al., 2008) embedded in the stream. For control trials, scrambled images of the same emotional distractor images were used. The emotional distractor image appeared at the 1st, 2nd, 3rd and 4th position in the RSVP stream. The target image was placed at positions relative to the distractor image according to the lag which were 1,2,6 and 8. At the end of the trial the participants were asked if they saw the tilted image. They were asked to report the orientation of the target as 'Left' (Alt key) and 'Right' (Ctrl key). In experiment 1, there were two word repetition conditions: In one block , participants had to repeat a word loudly three times as it appeared on the screen three times. RSVP task followed after the word presentation. In another block, the word was presented just once on the screen and participants were not required to repeat the word.The duration of the word presentation was 500 ms. In experiment 2, design was the same with one block thirty word repetition and another block no word repetition but just presentation.

In experiment 1 The four way repeated measures ANOVA - 2 (three repeat , no repeat) × 2 (word type: emotion word ,control word) × 2 (image type: emotion ,scrambled) × (lags: 1,2,6,8) was carried out. There was a significant main effect of image type on percentage accuracy ($F (1, 11) = 13.984$, $p = 0.003$, $\eta 2p = 0.560$). There was also a significant main effect of lag on percentage accuracy ($F (3, 33) = 22.782$, $p < 0.001$, $\eta 2p = 0.674$).For experiment 2 , The four way repeated measures ANOVA - 2 (thirty repeat ,no repeat) × 2 (word type: emotion word ,control word) × 2 (image type: emotion ,scrambled) × (lags: 1,2,6,8) was carried out. The main effect of repeats on percentage accuracy was indicated by ($F (1, 11) = 7.956$, $p = 0.017$, $\eta 2p = 0.420$) and it was statistically significant. The post-hoc comparison by using Bonferroni test showed a significant difference in accuracy between a group with thirty repetitions and a group with no repetitions ($t = 2.821$, pbonf = 0.017). There was statistically significant interaction between repeats, word type and lag ($F (3, 33) = 6.444$, $p = 0.001$, $\eta 2p = 0.369$).

The current study looked at the effect of semantic satiation on perception of affect in an attentional task. In experiment 1, there was no significant effect of three repetitions on performance in emotion-induced-blindness paradigm. The accuracy of the participants increased as the lag between emotional distractor and target increased and for scrambled images, we obtained high accuracy from participants in both control word and emotion word. Thus just speaking out an emotion word three times did not have any effect on the EIB-task performance. In the second repetition, with thirty repetitions, the accuracy of participants increased even at the shorter lags like lag 2. Interestingly in this study, we also observed that even in the presence of scrambled images, an emotion word alone was sufficient to give rise to an EIB like effect. Then when you repeat the word thirty times that is satiate the word , it increases the accuracy of target detection. This effect was not seen in case of control words.The current findings highlight the language-as-prior hypothesis for constructionist accounts of emotions. However it is important to note that emotion-induced-blindness task does not give any direct measure of how affect gets perceived. Rather it is an indirect measure of how attention gets influenced whenever an emotional stimulus intrudes in the task.

# Emotion and Driving: Exploring the Influence of Emotional Stimuli On Accidents while Driving

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Introduction

Driving is a complex motor skill that requires mastery through practice. It involves precise coordination of hands and feet, hand-eye coordination, fine motor skills, and spatial perception. Over time, drivers may develop automaticity, allowing them to perform tasks with minimal conscious effort. However, driving remains a closed-loop skill, necessitating continuous monitoring and real-time adjustments based on sensory feedback (Magill & Anderson, 2017). This skill involves processing information in real time and adjusting to achieve precise movements and error correction, which is vital for safe and effective driving. Fuller's Task Capability Interface Model (TCI, 2005) highlights that driving skills become more automatic with practice but never fully automate. It explains how drivers assess safety margins, with task difficulty linked to specific demands and driver abilities, influenced by physical and cognitive factors. When capabilities exceed demands, tasks are easy; when they match, they are challenging; when demands surpass capabilities, it can lead to difficulties. Self-assessment of capabilities varies based on personal performance, affecting drivers' response to situations and road safety. However, discussions about road safety often overlook the role of emotions. Emotions are "complex psychological and physiological states that include a variety of thoughts, feelings, actions, and physiological reactions. They are often felt as moods that arise in response to various internal and external inputs, including events, memories, perceptions, thoughts, and social interactions" (Jeon, 2017). Emotion can affect decision-making (Mohanty & Suar, 2014), emotional content can be distractive (Chan & Singhal, 2013), and can affect driving performance (Sullman & Dorn, 2019). Negative emotionally loaded distractions can impair control (Chan et al.,2015), increase speed (Kadoya et al.,2021), and lead to quicker but delayed braking. Even individuals with high anger tendencies tend to drive riskier (Yu et al., 2022). Conversely, those with high emotional intelligence drive more safely (Ahmed et al., 2022). Another study concluded that negative mood states have a more substantial influence than positive mood states on driver behaviour, leading to increased risk-taking behaviour (Hu et al., 2013). Emotions span from mild anxiety to extreme feelings, accompanied by physiological and behavioural responses. Managing these emotions is vital for road safety.

Research Gap and Motivation: This study aims to explore the impact of emotions, broadly categorized as pleasant and unpleasant, on their role in road accidents. Emotions will be induced using images from the International Affective Picture System (IAPS) database. Participants will then navigate challenging scenarios in a driving simulator, including unsignalized intersections with continuous traffic on the major road and sudden pedestrian crossings. The study hypothesizes that (i) there will be a significant difference in the number of accidents across different emotional states and that (ii) negative emotions will lead to more accidents compared to positive emotions.

Methods

An extensive literature review was conducted to investigate the impact of emotions on driving behaviour and their role in road accidents. Based on this, it was hypothesized that different emotional states would lead to varying numbers of accidents, with negative emotional states resulting in more accidents than positive emotional states. The emotional states were induced using the International Affective Picture System (IAPS) (Branco, 2023; Lohani et al., 2013). Images were categorized based on valence (positive or negative) and arousal (intensity of emotion). Three emotional conditions were considered: pleasant (positive and high arousal), unpleasant (negative and high arousal), and neutral (standard images for comparison), which were randomized for each participant. After pleasant and unpleasant emotional states, the participants were exposed to a neutral state to normalize the mood. The study involved 95 young drivers and used a fixed-base driving simulator. The participants viewed 30 IAPS images to induce mood and had to drive through a challenging urban road scenario involving unsignalized intersections and sudden pedestrian crossings.

Methodology used for the present study

Results

The following diagram depicts the average and the standard error of accidents during different emotional states.

Repeated measures ANOVA was carried out to find the differences in mean, and it was backed up by post hoc analysis.

From the ANOVA table, it can be deduced that emotion significantly affects the dependent variable, the number of accidents. With a very low p-value (< .001) and a moderate effect size ($\eta^2 = 0.155$), it is clear that the emotional state significantly influences the observed differences in the number of accidents.

Post-hoc tests or pairwise comparisons were conducted to further understand these differences to identify which specific emotion groups differ significantly. The post hoc tests show no significant difference between the number of accidents in pleasant and neutral emotional states, as indicated by the non-significant p-value (1.000). However, there are highly significant differences between pleasant and unpleasant emotional states and between neutral and unpleasant emotional states, as indicated by the very low p-values (< .001).

These findings suggest that the differences in the number of accidents are primarily driven by the contrast between the unpleasant emotional state and the other two levels, pleasant and neutral emotional states.

Discussion:

The study's findings indicate that participants were involved in a notably higher number of accidents when they experienced unpleasant emotions than pleasant or neutral emotional states. This outcome aligns with the study's formulated hypotheses, which predicted a significant difference in the number of accidents across various emotional states and a higher likelihood of accidents when negative emotions were present as opposed to positive emotions. It is worth noting that the absence of a significant difference between the number of accidents in pleasant and neutral emotional states had been observed in prior research (Kadoya et al., 2021). However, this observation could be attributed to limitations associated with the research tool used for emotion induction.

# Imagery Rescripting and Imaginal Extinction in Reducing Generalized Fear: A Comparison

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Introduction

Imagery Rescripting (ImRS) and Imaginal Extinction (IE) are promising visual mental imagery-based interventions for treating anxiety and related disorders. Imagery rescripting is a UCS devaluation process in which the participants are asked to mentally devalue an aversive situation and modify it in a desirable direction (Woelk et al., 2022). In contrast, in imaginal extinction, the participants are verbally instructed to vividly imagine the conditioned stimuli 'before their inner eye' (Agren et al., 2017). Extant literature suggests that ImRS and IE may effectively reduce conditioned fear responses, i.e, expectancy ratings and skin conductance responses (Kunze et al., 2019). However, their impact on reducing generalized conditioned fear responses has not been investigated. The current study aimed to compare the effectiveness of imagery rescripting, imaginal extinction, and standard extinction (SE) in reducing generalized fear responses.

Methods

A two-day fear generalization paradigm was performed with ten rings of gradually increasing size, with the largest and the smallest rings as the conditioned stimuli (CS+ and CS-) and the intermediate rings as generalization stimuli (GS); an aversive image of a house on fire from International Affective Picture Database (IAPS) (picture no. 9623) was used as the unconditioned stimulus (UCS) (Struyf et al., 2018). G*power analysis with $\alpha$=0.05, power= 0.80, and effect size f= 0.25, the sample size required for 3 (group) x 5 (phase) ANOVA was 27. Hence, 42 healthy participants (M= 18.83, SD= 0.44) were randomly assigned into three intervention groups, imagery rescripting (ImRS), imaginal extinction (IE), and standard extinction (SE). The study comprised five phases; Day 1 included habituation, fear acquisition and fear generalization. In the habituation phase, the CS+ and CS- was presented four times each. In the acquisition phase, the participants were presented with the UCS and a narrative on how a house was on fire and a little boy caught in the fire could not be saved. The participants vividly imagined the narrative for 3 minutes. Further, the CS+ and CS- were presented 8 times each in a pseudorandom order. The CSs were presented for 4000ms. The UCS immediately followed the CS+ for 75% of the trials (6 out of 8 trials) for 2000ms, and the CS- was never followed by the UCS. The CS+ and CS- were counterbalanced across participants.

In the generalization phase, CS+ and CS- were presented 8 times each, the CS+ was followed by the UCS for 75% of the presentations to prevent the extinction of the conditioned fear. The four classes of generalization stimuli were presented 8 times each (each GS was presented 4 times). The CSs and GSs were presented for 4000ms each with a randomized inter-trial interval of 10000ms to 12000ms. On Day 2, 24 hours after fear acquisition, the intervention was conducted on the consolidated fear memories, followed by a generalization test. In the imagery rescripting group, the participants were presented with a narrative with a favourable outcome where the boy was saved from the fire. The participants were then asked to vividly imagine and create a mental representation of the alternative scenario for 5 minutes. This was done to devalue and reduce the negative valence of the UCS. This was followed by an extinction phase where the CS+ and CS- were presented 10 times each without the UCS. In the imaginal extinction group, the participants were presented with the corresponding visualization cues of the CS+ (large ring, large circle, large moon) and the CS- (small ring, small circle, small moon). In each trial, the participants were presented with a visualization cue for 4000ms and were asked to create a mental representation/ imagery of the corresponding CS (CS+/CS-) for 7000 ms. The UCS was not presented in this phase. The CS+ and CS- were presented 10 times each in the standard extinction group without the UCS. UCS expectancy ratings, valence and arousal ratings were the outcome measures.

Results

There was no significant difference in the UCS Expectancy ratings across the three intervention groups in the Acquisition, Generalization, Extinction and Generalization Testing phases. Hence, the results indicate that the three interventions had a comparable effect on the expectancy ratings in extinction and generalization testing. A significant group x phase interaction effect [$F(6,117) = 2.519$, $p= 0.025$, $\eta p2= 0.823$] of the CS+ valence was observed.

Discussion

The current study is the first to explore the effect of imagery rescripting and imaginal extinction on generalized fear. In the acquisition phase, differential fear conditioning to the CS+ and CS- was observed. In the generalization phase, fear associated with the CS+ generalized to the other generalization stimuli with higher expectancy ratings for stimuli similar to the CS+. In the extinction phase, the expectancy ratings for the CSs declined, however we did not find any significant group differences. In the generalization testing phase, we observed that the expectancy ratings declined more for the ImRs and SE groups. However, in the SE group, the extinction effects were more generalized, indicating a possibility of return of fear. Further, after the extinction phase, the CS+ valence of the ImRS group was higher than the other groups indicating a possible effect of UCS devaluation. Hence, ImRS may be more effective in reducing generalized fear as it increases the CS valence through UCS devaluation.

## Investigating Acquired Equivalence in Conditioned Pleasant and Unpleasant Stimuli

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Introduction:
Acquired Equivalence refers to a type of conditioning that occurs when two dissimilar stimuli get associated if they are followed with the same consequence (Hall et al., 2003). Due to this association, any change in the consequence of one stimulus may also transfer to the other stimulus. To explain the phenomenon of transfer of learning in acquired equivalence, some theorists have proposed response-mediated generalisation. When an association of A-B and C-B is formed, the presentation of A or C produces an internal representation of B. If another association of A and D is formed, a link A-(B)-D is generated. When C alone is presented, B acts as a mediator to generalise D to C and thus create C-(B)-D association. Thus, B, a common mediator between A and C, facilitates the acquired equivalence effect (Urcuioli, 1996). The current study assessed the acquired equivalence phenomenon in geometrical shapes with pleasant and unpleasant auditory stimuli. The experimental study design followed a Pavlovian conditioning model and utilised a trace conditioning protocol. We attempted to establish acquired equivalence in the auditory conditioning paradigm.

Method:
The study consisted of experiments 1A and 1B. Experiment 1A was conducted for stimulus-selection of auditory stimuli across valence and arousal dimensions for experiment 1B. 10 pleasant and 10 unpleasant auditory stimuli were selected from the International Affective Digitized Sounds Database (IADS-2) (Lang, 2007). Valence and arousal ratings of 10 participants (male=5 and female=5) were taken on the Self-Assessment Manikin scale (SAM:9-point Likert rating scale). Two auditory stimuli with the highest pleasant and lowest unpleasant valence ratings were selected as unconditioned stimuli (UCS). The auditory stimuli were selected based on only the valence ratings. Experiment 1B consisted of 13 participants (male=9, female=4). Four geometrical shapes (square, rhombus, triangle and star) were selected as conditioned stimuli (CS). The experiment was divided into habituation, acquisition, and transfer-testing phases. The habituation phase consisted of 16 trials of the 4 geometrical shapes presented for 1 second, each repeated 4 times. An inter-trial interval (ITI) of 4 seconds was presented after each trial. After the 16 trials, valence and arousal ratings were recorded for each shape, with a fixation of 1 second after each rating response. The acquisition phase consisted of stages 1 and 2. In stage 1, two shapes were paired with an unpleasant sound, and the remaining two with a pleasant sound. The geometrical shapes were presented for 1 second, followed by the auditory stimuli for 4 seconds with a total of 24 trials, with each shape-auditory stimuli pair repeated 6 times and an ITI of 4 seconds. Expectancy ratings were recorded after each UCS presentation. After the 24 trials, shape valence, arousal and contingency ratings were recorded. Stage 2 included a reversal of UCS, i.e., one of the shapes previously paired with the unpleasant sound was paired with a pleasant sound and vice-versa. The timing of stimulus presentations remained the same as in stage 1. A total of 12 trials with each pair repeated 6 times were presented. Expectancy ratings were recorded after each trial. Contingency ratings were recorded after the 12 trials. In the transfer testing phase, valence and arousal ratings for the shapes were assessed for any changes. The shapes associated with pleasant and unpleasant auditory stimuli in stage 1 and with unpleasant and pleasant auditory stimuli in stage 2, were termed P1 and U1, respectively. The shapes associated with pleasant and unpleasant auditory stimuli in stage 1 and not presented in stage 2 but evaluated for the transfer of unpleasant and pleasant conditioning in phase 3 are termed P2 and U2, respectively.

Results:
Valence and arousal ratings were recorded to assess whether a transfer of unpleasant to pleasant conditioning and vice versa occurs on 4 geometrical shapes from stage 1(24 trials) to stage 2(12 trials). A non-parametric Wilcoxon signed-rank test was conducted to determine whether there was a difference in the valence and arousal ratings of the four shapes. Results indicated significant differences in P1 valence ratings ($z=-2.413$, $p=0.016$), U1 valence ratings ($z=-2.466$, $p=0.014$), P1 arousal ratings ($z=-2.448$, $p=0.014$) and U1 arousal ratings ($z=-2.422$, $p=0.015$). There were no significant differences in the P2 and U2 valence and arousal ratings. A non-parametric Friedman test of differences among repeated measures was conducted for contingency ratings for stages 1 and 2 and rendered a Chi-square value=2.321 for stage 1, which was not significant ($p=0.509$), and a Chi-square value=11.880 for stage 2, which was significant ($p=0.008$). For the expectancy ratings, the Friedman test rendered a Chi-square value=4.410 ($p=0.220$) for stage 1 and a Chi-square value=2.273 ($p=0.132$) for stage 2, both of which were not significant. A Wilcoxon signed-rank test was conducted to determine whether there was a difference in stage 1 and stage 2 U1 and P1 expectancy ratings. Results indicated significant differences in P1 ratings ($z=-2.005$, $p=0.045$) and no significant difference in U1 ratings.

Discussion:
A significant conditioning transfer was observed for shapes undergoing direct counterconditioning. However, no significant transfer was observed for the shapes not presented for direct counterconditioning in stage 2. This might be due to the CS-UCS association of the geometrical shapes evaluated for transfer of reversal of UCS and the nature of CS. The results

suggest that direct counterconditioning may prove as an effective method to condition a stimulus from pleasant to unpleasant dimensions and vice-versa. In our study, we could not find substantial result for the acquired equivalence effect. However, assessing the acquired equivalence effect may require further in-depth research to unravel the underlying mechanism of such complex processes.

## Association between Cortical Reactivity and Cognitive Functioning in Schizophrenia: A TMSEMG Study

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INTRODUCTION:

Cognitive impairment is central to Schizophrenia (SZ). However, its underlying neurobiology is not well established.

Evidence from animal models and neuroimaging studies indicates a relationship between SZ and GABA and glutamatergic dysregulation in the brain. Further, clinical studies and in vivo studies show that this imbalance in excitatory-inhibitory neurotransmission contributes to cognitive deficits1. Transcranial Magnetic Stimulation-Electromyography (TMS-EMG) studies provide an opportunity to understand the neurobiology of cognitive impairment in SZ, specifically through measures of motor cortical reactivity2.

A few studies have investigated the relationship between TMS-EMG parameters and cognition. Short interval intracortical inhibition (SICI) as well as Long-interval intracortical inhibition (LICI) studies show that cognitive deficits, especially working memory in schizophrenia might be linked to a decline in GABA receptor–mediated inhibition3. No studies have investigated relation of intracortical facilitation (ICF) and cortical silent period (CSP) with cognition in SZ using TMS-EMG. We examined the association between a range of cortical reactivity and cognitive measures in a group of schizophrenia participants. We hypothesized that greater cortical inhibition and lesser cortical excitability will be associated with better cognitive performance.

METHODS:

Thirty-nine consenting right-handed participants with schizophrenia on antipsychotics were recruited for a clinical trial using neuromodulation. They underwent assessments of cognition using the Brief Assessment of Cognition in Schizophrenia (BACS) and TMS-EMG experiments. BACS evaluated six domains: verbal memory, working memory, motor speed, verbal fluency, attention and speed of processing and executive function. SICI and ICF were examined using a subthreshold priming pulse administered 3ms and 10ms before a suprathreshold test pulse, respectively. LICI was examined using suprathreshold pulse priming and test pulses 100ms apart. CSP was assessed by administering a suprathreshold pulse when the hand muscle was voluntarily contracted, and the ensuing isoelectric period on EMG was measured. Twenty trials of all the above parameters were performed. The association between the composite BACS score and the four cortical reactivity parameters was estimated using Spearman's Rho correlation with Bonferroni correction for multiple hypothesis testing. We also explored association of these reactivity parameters with the standardised domain scores of BACS.

RESULTS:

The mean age of patients was 32.97±7.1. 24 participants were females and 15 participants were male. Shapiro-Wilk Test was performed to check for normality. LICI, SICI, CSP and ICF were not normally distributed. Hence, Spearman's rho was tested and we observed that cortical reactivity was not significantly associated with BACS domain or composite scores at the Bonferroni corrected p threshold of 0.0015. On secondary exploratory analyses, we found that SICI ($\rho$=0.360, p=0.04) and LICI ($\rho$=0.335, p=0.027) were positively correlated with motor speed.

CONCLUSIONS:

In this group of schizophrenia participants, we did not find a significant relationship between cortical reactivity and cognitive performance, except for a possible association between speed of processing, which involves motor functions, and GABAA and B-mediated cortical neurotransmission (SICI & LICI respectively). The lack of association with other cognitive functions may suggest a region specific individual variation in the GABAergic dysfunction. We may need to evaluate the cortical reactivity at specific regions implicated with the respective cognitive functioning using modalities like TMS-EEG4.

**Post Acute Sequelae of SARS-CoV-2 and Cognitive Functioning (≥) 1 year post onset of infection**

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Introduction:

The COVID-19 pandemic has claimed over 6.9 million lives, with India alone recording more than 500,000 deaths. Beyond the immediate impact of the COVID-19 pandemic, survivors of the viral infection often find themselves grappling with persistent and incapacitating symptoms (Carfi et al., 2020). Termed as PASC (Post Acute Sequelae of Covid) when symptoms persist beyond 90 days (Holms, 2022), these sequelae prevent individuals from achieving pre-illness levels of functioning (Mahmud et al., 2021). Cognitive manifestations in PASC, encompassing attention, executive functions and memory, collectively termed as Brain Fog, significantly contribute to these challenges (Carfi et al., 2020). The SARS-CoV-2 infection is known to provoke a profound pro-inflammatory response, persisting even post remission from the viral infection (Holms, 2022), which may correlate with symptoms of brain fog (Vyas et al., 2021). Whether this pro-inflammatory response and cognitive sequelae subside with time or persist beyond one year remains elusive.

Rationale:

Therefore, this study sought to investigate whether: a) there was cognitive decline in individuals with PASC > 1 year post onset of infection, in comparison with healthy controls (HC); b) there was a difference in concentration of inflammatory markers (TNF α and IL-10) in individuals with PASC and HC; c) there was a relationship between concentration of inflammatory markers and cognitive performance. Appropriate hypotheses were framed to suit the above investigations.

Methods:

An a priori power analysis was conducted using G*Power version 3.1.9.4 to determine the minimum required sample size to test the study's hypotheses. Results indicated that the required sample size to achieve 90% power for detecting a medium to large effect at a significance criterion of α = .05 was N=34 per group for a test of mean difference (independent groups) and N=75 for a test of correlation. The sample recruited therefore consisted of 80 participants; n1=40 in the PASC (case) group and n2=40 in the Healthy Control (HC) group; with a mean age of 30.6 years. MedCalc Software was used to match controls to cases with respect to age and years of education. Owing to the lack of an identified biomarker that characterises PASC; this study followed the same route as other studies in the scientific literature. The inclusion criteria for the PASC group was documented history of SARS-CoV-2 infection prior to June 2022 and the presence of at least one symptom of PASC (given by CDC). The inclusion criteria for the HC group was the absence of any symptoms of PASC; and no documented history of SARS-CoV-2. Exclusion criteria for both included history of other chronic respiratory illnesses/ diagnosed neurological/psychiatric illnesses.

Participants were administered Montreal Cognitive Assessment (Global Cognition), Victoria Stroop Test (Response Inhibition), Berg's Card Sorting Test (Set Shifting), Digit Span Test (Working Memory) and Mackworth Clock Test (Sustained Attention) on PEBL (Mueller & Piper, 2014). Adequate breaks were given in between the tests to avoid mental fatigue. Serum assays were performed for detection and quantification of TNF-α and IL-10 in duplicates using appropriate ELISA kits.

Results:

The HC group performed better on tests of global cognition ($p = 0.008$; $d = 0.661$); working memory ($p = 0.007$; $d = 0.624$); and sustained attention ($p<0.001$ for false alarms; $p=0.048$ for correct targets); and the PASC group had a higher serum concentration of TNF α ($p=0.0039$). Furthermore, a significant inverse relationship between serum TNF α concentrations and global cognition (Pearson's $r= -0.512$; $p<0.001$) working memory (Pearson's $r=-0.632$; $p<0.001$) and sustained attention (Pearson's $r = -0.671$; $p<0.001$) was observed. A hierarchical regression was performed to control for the potential impact of age and years of education on cognitive and biomarker variables.

Discussion:

This study presents evidence of a protracted, persistent cognitive decline in individuals with PASC, elevated expression of serum TNF α; and a moderate to strong, significant inverse relationship between the two; at a median of 580 days post SARS-CoV-2 infection, after controlling for the potential impact of age and years of education of participants. The present results align with previous research indicating a link between systemic inflammation, neuroinflammation and cognitive decline. Mazza et al. (2021) identified systemic inflammation as a predictive factor for neuroinflammation. Clark et al., (2010) elaborates on potential mechanisms through which TNF could affect cognitive function; including but not limited to TNF 's role in mediating CNS damage under chronic inflammation, the activation of microglial cells within the CNS in response to peripherally increased TNF concentrations; and TNF's ability to promote the expression of other proinflammatory cytokines.

The significance of the present findings may be summarized as follows: a) it informs healthcare providers about the need for interventions catering to individuals experiencing PASC even > 1 year post onset of infection; b) it highlights the relationship between TNF α and cognitive decline observed in PASC; and c) it could lead to the development of therapeutic plans targeting TNF α to alleviate cognitive symptoms in PASC (future implications).

# Measuring Masking Among Autistic Adults: A Pilot Study

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Introduction

Autism is a neurodevelopmental condition that affects sensory modalities and social communication with broad-reaching implications for how people perceive their social environment. Masking is a phenomenon that occurs in Autistic people wherein they hide their Autistic traits in order to avoid ostracization and other negative social consequences. Subjective reports from Autistic individuals have observed that stigma and a perception of difference in the way Autistic people are treated leads to masking as a form of harm avoidance (Miller et. al., 2021).

The conceptualization of masking also has clinical significance for any interventions designed for Autistic individuals, as they had not taken it into account. It is a relatively new area of research in Autism, and the work done so far has focused on the phenomenology of masking, using qualitative methods such as interviews. The next step in this direction must be to create measurable constructs, in order to further quantitative research in this area.

It is possible that masking creates barriers to Autism diagnosis and has a negative mental health effect on Autistic people. However, these relationships cannot be clearly defined and studied quantitatively until there is an objective measure of masking that accounts for its many aspects. Currently there is only one such measure, the Camouflaging Autistic Traits-Questionnaire (CAT-Q) (Hull et. al., 2019). This increases the possibility of gaps in measurement, and provides no alternatives in case the CAT-Q is deemed unfit for use in any specific scenario. The aim of this study was to create a scale to measure masking in Autistic adults and conduct a pilot study to test its efficacy.

Methods

Based on literature review, a proposed scale to measure masking was developed. A pilot study was conducted via Google forms, targeted at Indian adults aged 18-35 years from both Autistic (both self-diagnosed and professionally diagnosed) and non-autistic individuals (control group). Snowball sampling method was used and social media was used to advertise the study. The form contained an informed consent form, followed by demographic information, the PHQ-9 scale (Kroenke et. al., 2001) to assess depressive symptoms, GAD-7 scale to assess anxiety symptoms (Spitzer et. al., 2006), a brief autism scale called RAADS-14 (Eriksson et. al., 2013) followed by the pilot masking scale and the CAT-Q.

Results

A brief overview of analysis of the data collected so far is as follows.

Statistical analysis was conducted in Jamovi version 2.3. A total of 69 participants (Non-Autistic N=38, and Autistic N=31, of which 7 reported themselves as professionally diagnosed and 24 as self-diagnosed) answered the google form. One respondent was excluded for not fulfilling the age criteria. As the sample was not normally distributed, non-parametric statistical analyses were used.

Convergent validity was established through a significant positive Spearman correlation between Pilot Study scores and CAT-Q scores (Spearman's rho = 0.92, $p < 0.001$). The pilot scale showed good internal consistency as measured by Cronbach's alpha coefficient ($\alpha = 0.98$). The lowest item-rest correlation was 0.52 and only found in one item.

Kruskal-Wallis (One-Way Non-Parametric ANOVA) was conducted on the pilot study scores. There was a significant difference between the three groups (Non-Autistic, Professionally Diagnosed Autistic and Self-Diagnosed Autistic), with a strong effect size of 0.62. Post-hoc Dwass-Steel-Critchlow-Fligner Test was conducted, showing that the Professionally Diagnosed and Self Diagnosed groups were not statistically different in pilot study scores. Exploratory factor analysis was conducted based on parallel analysis, with principal axis extraction on oblique rotation. Only one factor was extracted (63.2% of variance).

Discussion

Masking is not a term or phenomenon that is unique to autistic individuals, but the way autistic individuals mask is unique to them — it is different due to the specific things that they mask, the strategies they use in order to mask, and the effort and consequences of this behavior (Sedgewick et. al., 2021). Outlining the cognitive, affective and behavioral components of masking can provide unique insight into how autistic adults navigate the world around them. This is an under-researched area for many reasons; due to the focus on Autistic children over adults, the misconception that Autistic people are not shaped by their experiences and what they grow up to learn about how society perceives them, and as well as the inclusion of the recent surge in 'self-diagnosis' among Autistic adults. This pilot study provided information on how masking affects Autistic individuals' perception of and participation in their social environment, and the similarities as well as differences between Self-Diagnosed and Professionally Diagnosed adults with Autism.

This test aims to build upon existing work on measuring masking by focusing on the experiences that increase the likelihood of masking behaviors, and the thoughts and cognitions that precede them. Through more rigorous testing of this scale, it could be used to differentiate between masking and psychological issues such as anxiety in both clinical and non-clinical populations. Future directions for this research include using larger samples to identify the specificity and sensitivity of this test.

**Altered brain connectivity in epilepsy and psychogenic non-epileptic seizures based on multivariate data-driven ICA: A machine learning study using fMRI**

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Introduction:

Epilepsy is one of the most prevalent chronic neurological diseases of the brain that can affect individuals of all ages. Idiopathic generalized epilepsies (IGEs) consist of syndromes known as juvenile myoclonic epilepsy (JME), childhood absence epilepsy (CAE), juvenile absence epilepsy (JAE), and epilepsy with generalized tonic-clonic seizure alone (GTCA). On the other hand, Psychogenic non-epileptic seizures (PNES) are epilepsy-like paroxysmal behaviors that resemble seizures but lack the biological mechanism underlying the epileptiform brain activity. IGE and PNES are two common neuropsychiatric conditions with several overlapping and distinct features1 as well as conditions that have similar clinical manifestations, with grossly normal structural MR imaging. The data signifying the bidirectional association of psychiatric comorbidities suggest that some of the pathogenic mechanisms operant may play a role in epileptogenesis2.Although IGE and PNES have often been related to the process of pathology are still poorly understood3. The current study aims to focus on identifying common and distinct network endophenotypes of IGE and PNES in whole-brain functional connectivity that are activated during resting state using a robust multivariate data-driven model-free independent component analysis approach and automated classification using machine learning algorithms.

Methods:

In this study, we recruited 46 patients with PNES and 40 with IGE for this study. Participants were instructed to remain quiet, relax, keep their eyes open, and refrain from specific thoughts during the scans. Resting-state fMRI data were preprocessed using SPM12 in MATLAB version 2021a. Spatial ICA, conducted using the GIFT tool, extracted independent components (ICs) from all participants. The analysis identified six resting state networks (RSNs): Default Mode Network (DMN), Central Executive Network (CEN), Auditory Network (AN), Somatomotor Network (SMN), Dorsal Visual Network (DVN), and Self-referential Network (SRN). One-sample t-tests were then employed to compare RSN differences between the PNES and IGE groups. Fast ICA algorithms estimated the features of the six RSN ICs, which were used for training machine learning models. Machine learning algorithms, including Random Forest, K-Nearest Neighbor (KNN), Decision Trees, Linear Regression, Multilayer Perceptron Classifier (MLPC), and Gaussian Naive Bayes, were used for classification, with a holdout strategy to evaluate classifier performance.

Results:

The analysis revealed increased overall connectivity in the lateral visual network among JME patients and reduced connectivity in default mode areas among PNES patients. In connectivity of areas of the default mode network to other adjacent networks was increased, including the left cingulate gyrus of the cingulo-opercular network, the left precentral gyrus of the somatomotor network, and the left prefrontal cortex from CEN. PNES also showed denser connectivity in selected DMN regions (lateral parietal). Best classification accuracy performance was observed with random forest and K-nearest of 90%(AUC-80.0%) and 80%( AUC-82%) respectively.

Discussion: This study utilized resting-state fMRI data from IGE and PNES patients, employing spatial ICs to explore differences in six RSNs between the two groups. The results demonstrated that IGE exhibited abnormalities in certain RSNs compared to PNES. Specifically, DMN showed reduced activity in IGE compared to PNES patients, while SMN and AN displayed similar activity between the groups. The lateral visual network exhibited mild increased activity in the IGE group relative to PNES, whereas FPN/CEN showed similar activity in both groups.Previous resting-state fMRI studies using ICA analysis in JME patients have shown increased functional connectivity in frontal regions of FPN, DAN, and DMN. Another study by Wang et al showed that patients with JME-GTCS had reduced connectivity in DMN, except for the posterior cingulate cortex and lateral temporal lobe, which showed increased connectivity 4. Other networks including visual networks, auditory networks, somatomotor and self-referential networks showed reduced connectivity. SMA, precentral gyrus, and superior parietal lobules; reduced coactivation was seen in the orbitofrontal cortex, with increased coactivation of insular and subcallosal cortex parts of CEN; increased activations of the cingulate and insular cortex in ventral attention network; and increased co-activation of the precuneus and paracingulate gyri in DMN.56

To classify IGE and PNES patients, we harnessed the spatial ICA properties of resting-state networks as machine learning features, employing the leave-one-out cross-validation method. The results indicate that Random Forest achieved the highest classification accuracy (94.00%, AUC-0.8), followed by K-Nearest Neighbor (80.0%, AUC-0.82). Data-driven approaches provide valuable insights into the study of functional brain networks, shedding light on the unique dynamics of epilepsy pathology. This study contributes to our understanding of normal and pathological brain networks, emphasizing the importance of accurate subject classification for evaluation purposes.

**Between Nutrition and Cognition: Is diabetic status a potential mediator between Vitamin B12 deficiency and cognitive functioning in rural Indians**

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Introduction

Vitamin B12, commonly known as cobalamin, is an essential water-soluble vitamin crucial for cellular metabolism. In older adults, the prevalence of vitamin B12 deficiency has been linked to cognitive decline. Simultaneously, diabetes, marked by persistent hyperglycemia and insulin resistance, is also a known contributor to cognitive deficits. The complex relationship between metabolic disorders and micronutrient deficiencies presents a considerable challenge in unraveling their combined effects on cognitive health. In this study, we aim to delve into this interaction through comprehensive biochemical and neuropsychological assessments. The focus of our investigation is the rural population of India, where the prevalence of vitamin B12 deficiency and diabetes are remarkably high, recorded at 42.3% and 25.7% respectively. Given the significant prevalence of both conditions, it becomes imperative to examine how their co-occurrence influences cognitive performance in the aging individuals of this demographic.

Methods

Baseline clinical and cognitive data were collected from 1571 community-dwelling middle aged and older adults from a prospective cohort study, Srinivaspura Aging, Neuro Senescence and COGnition (SANSCOG, n=6275) in rural villages of Karnataka, India. Cognitive evaluations were conducted using the Hindi Mental State Examination (HMSE) to assess global cognition and the Computerised Information Processing Battery (COGNITO) for specific cognitive domains. The HMSE serves as a tailored screening instrument for global cognitive assessment in the rural Indian population. Meanwhile, COGNITO is a culturally-adapted computerized battery for detailed domain-specific cognitive evaluations. Vitamin B12 concentrations were determined using chemiluminescence immunoassay, with levels below 200 pg/dl classified as deficient. Diabetic status was determined by measuring Glycated hemoglobin (HbA1c) values using high performance liquid chromatography (HPLC). Values below 5.7% were considered normal, values ranging from 5.7% to 6.4% were indicative of prediabetes, while those above 6.5% were categorized as diabetes. We used the Generalised Linear Model to investigate the main effects and interaction effect of Vitamin B12 level and diabetic status on cognitive functioning. In our analysis, Model was adjusted for age, sex, education, and cardiovascular risk factors like BMI, current smoking, alcohol consumption and hypertension.

Results

The mean age of participants was 56.45 ± 9.53years. The study observed a prevalence of 40.73% for vitamin B12 deficiency and 17.88% for undiagnosed diabetes. Following adjustments for potential confounding variables, analysis indicated a significant association with vitamin B12 deficiency with performance in cognitive tasks in COGNITO namely, stick construction test (B= 6.872, 95% CI= 1.856, 11.889, p=0.007), visuospatial span (B=0.385, 95% CI= 0.096, 0.673, p=0.009), visual attention (B=0.598, 95% CI= 0.015, 1.181, p=0.044), Geometric figures (B=0.378, 95% CI= 0.011, 0.744, p=0.044), and phonemic fluency (B= 0.545, 95% CI= 0.159, 0.931, p=0.006) out of the total 15 tests. No association was reported with respect to global cognition. Moreover it was demonstrated that diabetic status was significantly associated with HMSE (B=0.768, 95% CI= 0.180, 1.356, p=0.010), and cognitive performance in the stick construction test (B= 9.862, 95% CI= 4.098, 15.626, p=0.001). The interaction effect of Vitamin B12 and diabetic status was significant in the stick construction test (B= -9.184, 95% CI= -18.049, -0.318, p=0.042), visuospatial span (B= -0.554, 95% CI= -1.064, -0.044, p=0.033), and geometric figures (B= -0.827, 95% CI= -1.475, -0.179, p=0.012).

Discussion

The findings of this study demonstrates the profound cognitive impairments observed in individuals with concurrent vitamin B12 deficiency and diabetes, impairments not evident when these conditions occur separately. Specifically, we noted significant deficits in tasks involving problem-solving, visuospatial skills, and visual construction. These deficits are indicative of disturbances in frontal-subcortical circuitry and visual memory, potentially intensified by the cumulative neuroinflammatory impacts of both conditions. In conclusion, this study significantly contributes to understanding the relationship between Vitamin B12 deficiency, diabetic status, and cognitive health within the rural elderly population. The findings underline the critical importance of comprehensive cognitive assessments and timely interventions aimed at effectively managing metabolic imbalances and nutrient deficiencies in this demographic, to improve and preserve cognitive function.

## Cortical Correlates of Reinforcement Learning (RL) Deficits in Parkinson's Disease

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Introduction

Parkinson's Disease (PD) is characterized by the progressive loss of dopaminergic neurons of the basal ganglia resulting in motor and cognitive deficits. One of the cognitive processes affected in PD is Reinforcement Learning (RL), commonly known as reward-based decision-making. Although we know that disease phenotype and levodopa medication affect RL, the underlying neurophysiological mechanisms still remain unclear. A better understanding of these mechanisms is likely to fuel development of novel therapeutic strategies for restoring RL deficit. The current study aims to identify the EEG-based neurophysiological markers associated with RL deficits in PD patients using a data-driven approach and to investigate how levodopa (L-DOPA) impacts RL by modulating cortical activity patterns. Based on the evidence from current literature, we hypothesized that abnormal cortical oscillatory patterns, and interaction between them, would be linked to RL deficits in PD patients.

Methods

We have used an open-source dataset from OpenNeuro ( https://openneuro.org/ ) for this study. It consists of an EEG recording during a reinforcement learning (RL) task (Figure 1). PD patients underwent two sessions of the task recordings, one medication ON (MON) session and another with a 15-hour-overnight medication withdrawal (medication OFF, MOFF). We have used the Brainstorm toolbox in MATLAB for EEG data pre-processing and analysis. For pre-processing, the data were band-pass filtered (0.5-55 hz), bad channels were removed and interpolated. Since, we were interested in identifying neurophysiological markers associated with rewards, specifically positive reinforcement. We epoched the data -4000 to 1500 ms around positive feedback onset.ICA was applied to remove eye blinks and the data were then re-referenced to average, re-epoched (-500 to 1500 ms), and baseline corrected (-500 to 0 ms). The pre-processed data were time-lock averaged to obtain the event-related potentials (ERP) and later their time-resolved frequency characteristics were examined. Statistical Analysis: With a data-driven approach, we performed a cluster based t-statistic analysis to determine whether the ERP was significantly different across three conditions: HC, MON, and MOFF for specific time windows ($p < 0.05$, 1000 randomizations (Figure 2). Cluster-based correction addresses the multiple comparison problem in EEG data analysis by identifying clusters of contiguous data points with low p-values, using permutation testing to determine significant clusters. We performed time-frequency analysis using the Morlet-Wavelet Convolution method. An independent permutation t-test (n = 1500, for six regions of interests, frontal, midline and occipital electrodes) for comparing HCs and PD patients and a paired t-test for the medication groups of PD.

Results

We observed reward-locked ERP during the time window of 300-450 ms in all the three conditions (HC v/s MOFF , HC v/s MON, & MOFF v/s MON ($p< 0.05$). After extracting the sensor activity observed in all the ROIs, time-frequency analysis revealed a statistically significant difference in theta (5-7 hz) and gamma (30-55 hz) frequencies in HC and MON, HC and MOFF, and delta (2-4 hz) frequencies in MOFF and MON conditions.

Discussion

We performed an extensive data-driven analysis on the openly available EEG dataset to examine the neurophysiological correlates of the reinforcement learning (RL) deficit in patients with PD. (Our primary focus was the identification of markers associated with positive feedback. Consequently, we did not investigate negative feedback or prediction errors in this study. Our analysis was restricted to all trials involving positive feedback, reward, or positive reinforcement). Our results show that reward positivity is diminished in PD as compared to HC. It is possible that dopamine influences reward-related cognition based on differences between medication groups 2,3. Our findings provide conclusive evidence regarding the differences in neurophysiological activity between the HC and PD groups in the processing of positive outcomes 1. Moreover, the differentiation among medication groups aligns with the pivotal role of dopamine in human reward processing 3,4. The literature on oscillatory patterns while performing a cognitive task in PD is sparse and inconclusive. Alpha and theta oscillations in resting state EEG data have been linked to reward-based behaviour and apathy respectively 5. According to several studies, cognitive decline is associated with reduced connectivity in low-frequency theta to high-frequency gamma bands 5,6. Our time-frequency results revealed that PD patients exhibit an attenuated theta rhythm and enhanced gamma rhythm across the midline and occipital electrodes. The higher delta rhythm observed in MOFF compared to MON may stem from the possibility of the P300 component overlapping with the temporal window of the reward positivity 7. We are further investigating the correlation of these abnormal oscillatory patterns to RL and the relevance of cross-frequency interactions.

## Visual attention after treatment for congenital blindness

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Introduction

Project Prakash is a humanitarian and scientific initiative to treat children with curable blindness and with their help, understand visual brain development. The goal of this study was to understand how the visual attention system is impacted by early-onset and prolonged visual deprivation in a group of Prakash patients who had undergone treatment for congenital cataracts more than two years ago. A battery of tests assessing different aspects of attention was administered and the data obtained from these patients was compared with age and acuity matched control participants. Our results so far highlight the robustness as well as vulnerabilities of different aspects of attention to early visual deprivation. This investigation advances our knowledge of critical periods in visual development addressing the question of whether congenitally blind patients who have not had visual experience for the initial years of their lives, can attain attention levels that are comparable to neurotypicals, post-treatment.

Methods

Our test battery comprised a set of diverse visual attention tests, including pre-attentive pop- out, visual search, multiple object tracking, and visual short-term memory, each assessing a different aspect of visual attention. Nine patients (average age 18, SD: 5.8) and nine controls (Mean age: 18, SD: 1.2) participated, excluding one patient due to poor performance across all tasks. The patients were treated at different time periods from data collection ranging from 4 to 13 years (Mean time duration: 6.5 years, SD: 3.5 years). Control participants were made to wear blur-goggles to match their visual acuity with the patient group. The mean visual acuity of the control group was 20/442, while that of the patient group was 20/499. Brief descriptions of each task are as follows: Pre-attentive pop-out: is a task that probes primitive mechanisms that can detect patterns even without deliberate attentional deployment. It required pre-attentive search of a target bar oriented at a specific angle among homogenous distractor bars. Visual search: deploys selective attention and required participants to search for a target image presented as cue among distractor images. Multiple object tracking: deploys attention associated with moving objects and required participants to track moving targets among similar randomly moving distractors. Visual short-term memory: Employs visual working memory as a factor in attention deployment. The task required participants to recall the presence of a target block among distractors shown after a temporal interval.

Results

Each of the four tasks was individually analysed utilizing relevant statistical metrics. Key results for each task are outlined briefly: In the pre-attentive pop-out task, control group accuracy (83%) significantly surpassed patients group accuracy(67%) for target-present trials. Patients took significantly longer(4.22 msec) to identify target bars compared to controls(2.51 msec) at $p<0.05$. No significant differences in accuracy or reaction time were observed for target-absent trials.The visual search taskdisplayed comparable averageaccuracy between the two groups (control group = 99%, patient group = 95%). However, the patients group exhibitedsignificantly longer reactiontimes (4.21 msec) for target-present trials compared to controls (1.62 msec). The multiple objects tracking task, consisting four sub-tests of increasing difficulty, showed significant differences ($p<0.05$) in average tracking capacity between both groups across all sub-tests. Prakash participants were able to simultaneously track fewer entities than controls. The average tracking capacity (m) was calculated using the formula $m = n(2p-1)$ where, m indicates tracking capacity (i.e., corrected for guessing), n indicates number of targets and p indicated the proportion of correctly identified targets. The visual short-term memory task revealed a significant difference($p<0.05$) in average working memory capacity (K) between control group ($K = 8.76$) and patients group ( $K = 6.88$) for a stimulus duration of 2000 msec. No significant difference was noted for a stimulus duration of 4000 msec. Working memory capacity was computed using $K=n*(accuracy-1)$, where accuracy represents correct proportions across trials and n is the set size. There were no differences found based on time duration from surgery among the patients, however for such effects to be analyzed, the study requires a larger sample size.

Discussion

The primary level statistical analysis provides important insights into differences in attention levels of the two groups of interest. Each task assessed a distinct aspect of attention. The results reveal that while some measures of attentional abilities are present in Prakash patients after surgery, there are differences in the deployment time and memory capacity associated with these abilities. The relatively high number of ‘misses’ observed in patients can be interpreted as either due to a lack of attention, or a conservative decision bias. With the present study design, the latter cannot be definitively ruled out. Therefore, there appears a requirement of future experiments that record detection responses may be able to contribute to our understanding of this phenomenon. In the pre-attentive pop-out and visual search tasks, the presence of pre-attentive abilities and primary attention were measured and there was no significant difference between the accuracy of two groups, highlighting that that on this dimension the Prakash patients are comparable to controls. However, reaction times for this group were significantly higher.

In multiple object tracking, we found performance to be significantly different between the groups, indicating that Prakash patients were poor at this aspect of attention. In the visual short term memory task, the working memory capacity of attention differed significantly between the groups. Some of the major limitations of the study include a smaller sample size because of rare occurrence of the patient group. Overall, our data provide several insights into the status of attention in Prakash patients many years after their surgeries. Planned work includes EEG studies with this cohort to better understand the development of neurophysiological underpinnings of visual attention.

# Role of Attentional Control in emotional regulation in women suffering from Polycystic Ovary Syndrome (PCOS)

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Introduction

Polycystic Ovary Syndrome (PCOS) is a complicated endocrine illness affecting millions of women worldwide (Azziz et al., 2016). It is linked to various medical and psychological symptoms, such as hormone abnormalities, menstrual irregularities, and mental disorders, including depression and anxiety (Barry et al., 2011). PCOS remains a significant concern in women's health, necessitating a comprehensive understanding of its psychological aspects and underlying mechanisms. This study examines the relationship between attentional control and emotional regulation with PCOS. This research is necessary because it fills a gap in our understanding of how attentional control impairments may lead to emotional dysregulation in this population. Validated psychological measures were employed to achieve these objectives, and strict ethical guidelines were maintained.

Methods

Sampling and Participants: The study recruits a sample of 64 women aged 18 and 40, divided into a PCOS group (n=32) and a control group (n=32). Participants were selected through convenience sampling, primarily from clinical settings, support groups, and online communities focused on women's health. Measures: The Emotional Regulation Questionnaire (ERQ) was used to assess cognitive reappraisal and expressive suppression (Gross & John, 2003), and the Attentional Control Scale (ACS) was used to measure participants' attentional control abilities, including attention focusing and attention-shifting (Derryberry & Reed, 2002). The Berg Card Sorting Test was used to study set-shifting patterns (Berg, 1948). Study Design: This study employs a cross-sectional design to investigate the relationship between attentional control and emotional regulation in women with Polycystic Ovary Syndrome (PCOS). This approach offers insights into the current psychological state's impact on the quality of life.

Results and Analysis

Demographic data revealed that the average age of participants was 29.5 years (SD = 5.1), with 65% being married or in a committed relationship. Regarding education, 45% had completed a bachelor's degree, 30% had a master's degree or higher and the rest 35% completed matriculation. To characterise the research participants, descriptive statistics were used. The Shapiro-Wilk test was used to determine the normality of variables. The results showed a significant difference in the Total Attention Score between the PCOS group ($M = 38.12$, $SD = 6.24$) and the control group ($M = 44.28$, $SD = 4.19$) ($t(63) = -4.12$, $p < 0.001$). This finding confirmed the hypothesis, suggesting that women with PCOS experience difficulties in attentional control compared to their non-PCOS counterparts. Moreover, the Mann-Whitney U test revealed a significant difference in Attention Focusing between the two groups ($U = 202$, $p < 0.05$), reinforcing the initial hypothesis. Pearson Correlation analysis did not uncover a significant correlation between the Total Attention Score and Total Emotional Regulation Score in either group. However, a significant positive correlation emerged within the PCOS group between the subscales, specifically, attention-focusing and attention-shifting ($r = 0.40$, $p < 0.05$), as well as attention-shifting and Reappraisal Items ($r = 0.45$, $p < 0.01$). This specific connection highlights the role of Attention Focusing in cognitive reappraisal, a critical facet of emotional regulation. Attention Shifting emerged as a robust predictor of Emotional Regulation ($\beta = 0.52$, $p < 0.01$) and Reappraisal Items ($\beta = 0.49$, $p < 0.05$) in women with PCOS. This result emphasises the pivotal role of Attention Shifting as a foundational cognitive component contributing significantly to the development of effective emotional regulation strategies within this unique group. Notably, the Berg Card Sorting Test revealed that women with PCOS made significantly more errors (PCOS M=37, SD=9.8; Control M=29, SD=5.7), underscoring difficulties in cognitive flexibility.

Discussion

Previous research implicated hormonal imbalances, stress, and depression in emotional dysregulation in PCOS (Barry et al., 2011), inflammation, and oxidative stress (Luque-Ramírez & Escobar-Morreale, 2016). This study extended these findings by investigating attentional control, a crucial cognitive process underlying emotional regulation (Eysenck et al., 2007). The findings of this study aligned with prior research, confirming attentional control deficits in women with PCOS compared to controls. Differences in the Total Attention Score between the groups substantiated the hypothesis, emphasising attentional control's relevance in PCOS. Additionally, the study highlighted the role of Attention Focusing, further validating attentional control as a distinguishing feature of PCOS. Crucially, Attention Shifting emerged as a robust predictor of Emotional Regulation and Reappraisal Items in women with PCOS, emphasising its significance in effective emotional regulation. This study bridged a significant research gap by elucidating the intricate relationship between attentional control and emotional regulation in PCOS. Attentional control deficits provide a nuanced perspective on the cognitive aspects of PCOS-related emotional dysregulation. These findings offer promise for tailored interventions to enhance attentional control and, consequently, improve overall quality of life for women with PCOS.

**Inhibitory Control in obese young adults: Bottom-up effect of food cues in a Go/No-go task.**

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Introduction:
Obesity, marked by excessive body fat, adversely impacts health and has been associated with cognitive impairments affecting attention, memory, and executive function (Devoto et al., 2018). Various hypotheses, like the incentive-sensitization theory (Robinson & Berridge, 2008), suggest that the appeal of food can affect behavioral control, particularly in obese individuals who may struggle to inhibit automatic responses (Guerrieri, 2008). Inhibiting responses to tempting food cues is linked to overeating and weight issues (Price et al., 2016). However, empirical studies on the interaction between inhibitory control and obesogenic behavior have limitations, often due to differences in cue salience (Stice, 2019). Most research has focused on eating disorders, such as anorexia and bulimia (Bartholdy, 2016). Obesity's cognitive consequences likely result from the interplay of inhibitory control, food cue appeal, and reward motivation. Our hypothesis was that, even when salience levels were matched between neutral and food stimuli, food cues would exert a bottom-up influence on inhibitory control in obese individuals. This study aimed to investigate the impact of food cues on inhibitory control in obese and non-obese adults, with the expectation that food-based stimuli would have a stronger effect on inhibitory control among those with obesity.

Method:
35 obese (BMI >30; female waist-to-hip >0.80, male >0.94) and 35 non-obese (BMI 18.5-24; female waist-to-hip <0.80, male <0.94) participants were selected. Exclusion criteria included chronic medical conditions, eating disorders, neurological/psychiatric disorders, psychotropic medication usage, and substance abuse history through self-report measures - personal proforma, State Trait Anxiety Inventory, and Beck Depression Inventory. The experiment used food-based and transport items as No-go cues and household items as Go cues. Images were colored and adjusted for visual consistency. Participants, after image selection, were rated by a group of 30 healthy adults. The main task included 200 trials in two blocks, with 70% Go and 30% No-go stimuli. One block featured Household-Go and Transport-No-go cues, and the other had Household-Go and Food-No-go cues. Participants had 1000 ms for stimulus viewing and 500 ms for responding. They were instructed to respond to Go cues and withhold responses to No-go cues. Stimulus presentation order was pseudo-randomized, and blocks were balanced across participants.

Results:
Reaction times and error rates (%) were analyzed. After removing anticipatory and very slow responses using the Mean ± 3SD criterion, approximately 2% of the total trials were removed. A three-way ANOVA was performed on error-rates in a 2 (group: Obese, non-obese) x 2 (stimulus type: transport, food) x 2 (trial type: go, no-go) design. Overall, obese individuals had higher error rates ($F= 50.519$, $p < 0.001$). Error rates were higher in the food-block compared to the transport-block ($F = 219.342$, $p < .001$, $\eta^2 = 0.319$). There was a significant interaction between Stimulus Type and Group ($F = 26.358$, $p < .001$, $\eta^2 = 0.038$) and Trial Type and Group ($F = 19.296$, $p < .001$). There was also a significant three-way interaction ($F = 6.480$, $p = 0.013$, $\eta^2 = 0.004$). Post-hoc comparisons revealed that No-Go error rates were higher for food as well as transport stimuli for obese compared to non-obese participants. In addition, no-go error-rates for food stimuli were significantly greater for obese participants compared to nonobese individuals with a mean difference of -17.64 (95% CI: -23.32 to -11.96, $p < .001$). We also find a significant positive correlation between BMI and Waist to Hip Ratio ($r = 0.703$, $p < .001$). BMI and waist to hip ratio as an index of obesity was positively correlated with the No-Go error rates for food stimuli ($r = 0.610$, $p < .001$ and $r = 0.574$, $p < .001$ respectively).

Discussion:
The results confirm that obese individuals exhibit weaker inhibitory control, consistent with previous research and our hypothesis. Weak inhibitory control contributes to obesogenic behaviors (Batternick et al., 2010). Notably, our study improved on prior work by comparing salient-matched no-go stimuli (food and transport). Interestingly, we observed higher error rates for food cues in both obese and non-obese participants, despite matching salience. Food cues significantly impacted inhibitory control in obese individuals (de Klerk et al., 2022), reflected in higher error rates compared to non-obese individuals. The positive correlation between BMI/Waist-to-Hip Ratio and food cue errors underscores the roles of physical and cognitive factors in obesity's impact on inhibitory control. In conclusion, our findings highlight food cues' bottom-up influence on inhibitory control in obesity, suggesting potential interventions for healthier choices.

**Bipolar oscillations between positive and negative mood states in computational models using Interventional methods with an interactive-GUI**

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We build this work from our earlier works on the computational models of the Basal Ganglia for bipolar oscillations. Bipolar disorder is characterized by mood swings or oscillations between manic and depressive states. We have three models that represent a decision-making system, which works by choosing an action from a set of possible alternatives. A healthy state of the model tends to maximize the expected outcome by choosing the best options with maximum reward from the given set. The simplest model is a simple oscillatory dynamical system (A van der Pol-like oscillator) with at most two fixed points, which show limit cycle oscillations for specific values of the hyper-parameters (Model C, Balasubramani and Chakravarthy, 2019). Another Model (Model B, Balasubramani and Chakravarthy, 2019) is a decision-based model that maps the basal ganglia network functioning to the decision system. Lastly, Model A is a decision-based model that still has the basal ganglia neural components but in a abstract way. It uses reinforcement learning to choose actions at every time step, policy modeled as a Softmax Distribution over the value of an action chosen at a time.

In this conference paper, we explore the possibilities of adding constant interventions to the Utility of states (Value+Risk) and study the effect, and we stick to Models A and C for simplicity. These interventions resemble the external factors (value enhancers/devaluators or reducers, risk enhancers/reducers as translational interventions to the value and risk variable of the system) that affect the stability of certain mood states, for example, the oscillatory state in bipolar disorder. These interventions could also be some functions of rewards obtained or probability variations related cognitive restructuring, but, for simplicity, we consider constant interventions. Furthermore, using a GUI app, we explore various behaviors exhibited due to the added intervention via models A and C and, plot the Stability Analysis for various values of the interventions, and analyze the pattern that emerges with them.

Next, we aim to apply our model to investigate how a "wheel-of-fortune" can affect mood changes and fit our model to various participants playing the two alternative choice game with an added wheel of fortune that can offer randomly either a reward or a punitive jackpot to the participant (in collaboration with Dr. Mason at UCL). In future, we aim to translate this application to characterize bipolar participants efficiently and strategize their treatment in a personalized fashion.

**The effect of performance and sensory errors on visuomotor adaptation**

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Introduction:
The human motor system has a remarkable ability for adaptive motor learning, which can be driven by different sources of errors such as sensory prediction errors (SPE), known as the difference between actual and predicted sensory outcomes, as well as task or performance-based errors (TBE), defined as failure to achieve the task goal. Typically, in most visuomotor rotation tasks, these error signals co-occur. Therefore, the contribution of distinct error signals to different aspects of motor adaptation, such as learning, retention, savings (faster re-learning), and generalization (transfer of learning), is typically inferred by an inverse approach. Such studies have elegantly suggested the contributions of two systems to motor learning: one characterized by fast learning, savings, and the absence of retention, i.e., the extent of unlearning and another system characterized by slower learning that displays a lack of savings and better retention. Motivated by these results, we used a forward approach to study the contribution of sensory prediction errors (SPE) and task-based errors (TBE) to motor adaptation and study the properties of the learned behavior; for example, in a Target Jump task, the perturbation is introduced by shifting the target location during the mid-movement of reaching. This leads to failure to achieve the task goal, thus generating TBE signals, which the subject needs to counter with a strategic movement. In contrast, in a Gradual Rotation task, there is an incremental increase in the angular offset between the cursor feedback and hand movement, causing SPE signals, which are autonomously adapted by the subject in the absence of a performance error. Using this forward approach, we tested whether the distinct errors generated from these tasks showed distinct properties like the time course of adaptation, the nature of savings, and retention.

Methods:
Experiment and Task Design: Subjects looked down upon a monitor (Dell 22-inch 60 Hz refresh rate) where the stimulus was presented and performed a reaching task by moving the stylus over a digitized tablet (XP-Pen Artist 22R Pro with a maximum report rate of 200 RPS) kept below the screen, visually occluding the hand movement while enabling the cursor on the screen as a proxy of hand location. All the tasks were developed on the NIHM MonkeyLogic platform – a MATLAB-based toolbox. In all the tasks, the subject performed a centre-out reaching task to four possible locations (0º,90º,180º,270º) in each space having an eccentricity of 10 cm from the centre location, having cursor feedback throughout the task. Further, these tasks have two sessions: A Training session where the subjects naïvely adapt to the perturbation and a Testing session where the subjects are re-exposed to the same perturbation. All task subjects were asked to precisely reach the target as early as possible. To date, we have performed the two tasks in two versions: a Target Jump and a Rotation Task (sudden and gradual). In the Target Jump task, once the cursor leaves the fixation circle, after 200 ms, the target jumps in a 30º counterclockwise direction at the same eccentricity as the original target. In the Rotation task, we divided the group depending on the rotation perturbation they received. One group experienced a sudden rotation perturbation where subjects experienced 30º angular offset (clockwise) between the cursor and the hand movement. The other group experienced an increment of 1º angular offset (clockwise) between the cursor and the hand movement in each reaching cycle (4 unique reaches = one cycle). Subjects were not given any information regarding target or cursor manipulation for their respective tasks. The primary variable of interest in this study is the hand deviation. The hand deviation was computed relative to the target location. This was done by estimating the angle between the vector connecting the start position to the original target and the vector generated by connecting the start position and hand position at the peak movement velocity. The velocity was computed as the first derivative of hand position data (filtered using a low-pass 10hz Butterworth Filter) in the X-Y coordinate system for a given trial. For the Training and Testing session of the task, the hand deviation was baseline-corrected for each subject. The baseline correction was done by taking the average hand deviation during the Baseline session and subtracting it from the hand deviation for the given trial during the Training and Testing session, respectively. Early learning is defined as the first ten cycles of the given session for each subject. Given the hand deviation, the learning was quantified by parameters like Percentage Adaptation and Average Hand Deviation. Percentage Adaptation was computed as net hand deviation compared to ideal hand deviation for a given cycle. At the same time, the Average Hand Deviation was computed as the average of four reaches for a given cycle. Further, to compute the Percentage Adaptation for the first ten cycles, the ideal hand deviation was set to 30º for Target Jump and Sudden Rotation Task, whereas 10º for Gradual Rotation Task as the maximum rotational perturbation on the tenth cycle is limited to 10º. Within-group differences for the given learning parameters were compared using a paired t-test after checking for normality with the Shapiro-Wilk Test. These parameters were only compared between Training and Testing sessions during the early learning phase. Further, we exclude trials in which the subject did not initiate any movement (peak velocity <5 cm/s) or trials with hand deviation more than 60º at peak velocity. The total exclusion was less than 3% from the entire dataset. All the plots and analyses were performed on MATLAB.

Results:
The subjects applied the strategy right in the early phase for the Target Jump task, which has TBE. They had faster learning during the training session. They displayed signatures of savings (faster re-learning) during the testing session and rapid unlearning (lack of retention) during the washout sessions in both post-training and testing phases (Figure 2). In contrast, the group that experienced gradual rotation showed slower learning, qualitatively displayed no savings signatures (faster re-learning) during the testing session and showed evidence of retention of the adapted perturbation during the washout sessions in both post-training and testing phases. Interestingly, the group exposed to the sudden rotation showed an intermediate effect in that the learning exhibited a combination of the learning attributes of the SPE and TBE-exposed groups. Further, we went ahead with the quantification of learning attributes. The groups performing Target Jump Task ($t(3) = -20.079$, $p > 0.001$), Sudden Rotation Task ($t(3) = -3.868$, $p = 0.03$) and Gradual Rotation Task ($t(3) = -6.026$, $p = 0.009$) indicated a significant difference in their Average Hand Deviation between the Training and Testing sessions at early learning phase.
A similar trend followed when we compared learning with another attribute, Percentage Adaption. All the groups, i.e., Target Jump Task ($t(3) = -20.079$, $p > 0.001$), Sudden Rotation Task ($t(3) = -3.877$, $p = 0.03$) and Gradual Rotation Task ($t(3) = -6.027$, $p = 0.009$) showed a significant difference in their Percentage Adaptation between the Training and Testing sessions at the early learning phase.

Discussion:
These preliminary results obtained, align with the previous study's findings of adaptation to target jump and gradual and sudden rotation perturbations. They show strong savings for TBE signals (target jump) and strong retention for gradual SPE signals (gradual rotation), and both when they co-occur during the task (sudden rotation). In Target Jump Task, the slow unlearning during the early phase (first cycle) of the washout phase could explain the lack of anticipation of perturbation removal, as subjects were unaware of it to recalibrate the movement strategy in the upcoming trial. This similar effect was fairly observed in a recent study where one group was instructed about perturbation removal before a washout session for a similar task, and another group was not. The group with prior instruction indicated rapid unlearning compared to the group without instruction. Our findings align with the existing notion that the successfully encoded TBE errors drive flexible strategic adaptive learning and are necessary for savings. In the Gradual Rotation Task, though qualitatively, the subject’s behavior did not indicate any signature of savings, upon quantification, the subjects indicated savings during the early learning phase. Possible reasons for such an outcome can be that there is no complete unlearning, and the retention of those learned errors persisted, leading to a faster recall when the subject re-experienced the perturbation. This finding aligns with the classical notion that the savings are the outcome of the retained memories of errors, which is implicitly driven by SPE. However, we need to test this result by increasing the number of washout cycles to achieve complete unlearning and test the volatility of the retained error-learned memory and its effect on savings. Further, in Sudden Rotation Task indicated a combined effect of SPE and TBE-based learning. However, the cause of savings remains scant, hence further modification in task design like increased cycle during the washout session and introducing no cursor feedback trial during the washout session needs to be tested. In the future, we hope to leverage these findings to study how these different learning systems interact.

# The Impact of Nondominant Hand Weight Training on Dual-Task Performance: A Comparative Study

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Introduction

Physical exercise's positive effects on cognitive function, particularly aerobic exercise, have received considerable research attention. However, it is emphasized less about the cognitive effects of resistance training, especially when focused on the nondominant hand. People pay less attention to each task when the demands of dual tasking exceed their attention capacity (Kahneman, 1973); this decrease in availability of attention for each task is termed interference. Increased understanding of clients' concurrent motor and cognitive task performance is essential for evaluating their daily functioning (Christofoletti, Andrade, Beinotti, & Borges, 2014; Haggard,Cockburn, Cock, Fordham, & Wade, 2000). This study investigates the dual-task performance of individuals engaging in weight training activities involving their nondominant hand and its effects on dexterity and cognitive tasks. This research seeks to bridge the knowledge gap in the fields of sports psychology, cognitive psychology, and occupational therapy The relationship between physical exercise and cognitive performance has been a topic of interest in psychology and sports. Most studies have focused on aerobic exercises and other forms, with less attention given to resistance training, particularly involving the nondominant hand . The study is motivated by the need to understand how weight training targeting the nondominant hand affects dual-task performance and understand the impact of resistance training, specifically in terms of dexterity and cognitive tasks, in comparison to individuals who do not engage in resistance training. With the imperative to uncover potential cognitive benefits associated with weight training, particularly when applied to the nondominant hand. The insights generated from this study could be invaluable in developing exercise programs designed to provide targeted cognitive benefits. The objective of this research is to evaluate the dual-task performance of individuals engaged in weight training, emphasizing the use of their nondominant hand, and to assess the impact of this training on manual dexterity and cognitive functions. Underpinning our study, The hypothesis framed for the research findings are that the weight- trained group exhibited significantly enhanced dual-task performance with their nondominant hand compared to the non-weight-trained group (H1: $p < 0.05$). Additionally, the weight-trained group outperformed the non-weight-trained group in bimanual dexterity of the MMDT (H2: $p < 0.05$).

Methods

The study design is a matched-group and experimental study. It involves 54 individuals [females=6, males=48, weight trained individuals group: n=27 ; control group: n=27, they are matched for age, gender, and handedness, was recruited using convenience and snowball sampling methods. To participate, individuals should have a MOCA score above 26.Inclusion criteria required participants to be aged 18-35, with the weight-trained group having at least 6 months of resistance training hitting 5-6 times per week and a Montreal Cognitive Assessment (MoCA) score of 26 or above. Exclusion criteria included ambidexterity. The study employed the Minnesota Manual Dexterity Test (MMDT) to measure dexterity, the Serial Sevens Subtraction Test (SSST) for cognitive tasks, and the Edinburgh Handedness Inventory (EHI) to assess handedness. The MMDT test comprises two subtest, placing test (1) where the participants should place the disk as fast as they can into the holes of the board using their non-dominant hand, (2) turning test where the participants will pick up the disc with one hand, Turn them with the other hand, and replace the disks back into the holes on the board

Procedure

Participants are initially screened for cognitive impairment using MOCA and to assess nondominant hand Edinburgh Handedness Inventory is used. Both weight-trained and non-weight-trained individuals performed turning and placing tasks of the Minnesota Manual Dexterity Test, measuring dexterity, as well as the Serial Sevens Subtraction Test to assess cognitive ability. All participants completed two trials for each subtest in the single- and dual-task conditions, and the averages of each pair of trials were used in the analysis.

Results

The results showed that the experimental group exhibited superior bimanual dexterity and cognitive performance during dual-task performance compared to the control group. In turning test in single-task results didn't meet the criteria for normality($p>0.05$), hence we will be doing Mann-Whitney U test for our hypothesis 2. Independent sample T-test will be done to test hypothesis1.

To test hypothesis 1, between the experimental and control groups about their bimanual dexterity where they perform turning test, Mann-Whitney U test will be done as the data are not normally distributed. As seen, setting the alpha level of significance as 0.05, the results ($p<0.05$) have shown that the mean of the experimental group in turning test in single-task performance is less than the controlled group ($p=0.002$), and it is perceived that the experimental group performs well in bimanual dexterity.

The mean of the experimental group in the placing task in dual-task performance is less than the controlled group, which implies that the experimental group performs faster and takes less time in dexterity involving the nondominant hand (T(df)=52.0, p=0.001). The mean of the control group was lesser than the experimental group in cognitive task at dual-task performance (T(df)=52.0, p=0.005).

Discussion

In line with Hypotheses 1, the experimental group outperformed the control group during dual-task performance. This was evident in two key aspects. First, the experimental group excelled in the placing task during dual-task performance, demonstrating quicker and more efficient dexterity involving the nondominant hand. This result highlights the adaptability of the nondominant hand in multitasking scenarios. Second, the experimental group also outperformed the control group in the cognitive task during dual-task performance. This finding suggests that weight training, especially when applied to the nondominant hand, can have a positive impact on cognitive performance in conjunction with manual dexterity tasks.

In agreement with Hypothesis 2, the experimental group exhibited superior bimanual dexterity compared to the control group during the single-task performance of the turning test. This outcome suggests that intensive weight training, emphasizing the nondominant hand, enhances bimanual dexterity. This finding aligns with prior research indicating that manual dexterity can be improved through training, with particular attention to the dominant and non-dominant hands. The dominance of the nondominant hand in this context is intriguing. Kimura and Vanderwolf (1970) suggested that the nondominant hand may have untapped potential for adaptability in weight training. One limitation is the potential for discrepancies in the weight training experience of participants in the experimental group. Variability in the intensity and duration of weight training among participants may have influenced the results. Additionally, external factors such as changes in the environment or unexpected events during the study may have introduced bias.

Another potential limitation is the practice effect, which could have affected the participants' performance during repeated assessments. The study's generalizability is also limited as the sample size and characteristics may not represent broader populations. Finally, the focus on dual-task performance as a measure of cognitive-motor integration may not fully capture the complex nature of cognitive function during physical activities.To address the limitations, further studies should consider more standardized weight training regimens and a larger and more diverse participant pool to enhance generalizability. Longitudinal studies could explore the long-term effects of nondominant hand weight training on cognitive and physical health.

Additionally, investigations into the specific neurophysiological mechanisms underlying the observed improvements in dexterity and cognitive performance would provide a more comprehensive understanding of the relationship between physical exercise and cognitive function. Furthermore, future research could explore the potential of weight training as a form of cognitive rehabilitation for individuals with cognitive impairments, such as those with mild cognitive impairment or neurological conditions.

In conclusion, the results of this study suggest that nondominant hand weight training can lead to enhanced bimanual dexterity and improved cognitive performance during dual-task activities. While there are limitations to the study, these findings contribute to our understanding of the cognitive benefits associated with weight training, especially when considering the nondominant hand.

# Intentions alter attentional control

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Introduction

The dynamic theory of intention (Pacherie, 2006) suggests that intentions play a crucial role not only at the action preparation stage but also in controlling and monitoring action execution and outcome. Multiple previous studies have demonstrated the effects of intended action on the perception of subsequent events. Not only is the outcome of an intended or voluntary action perceived temporally closer (Haggard, Clark, & Kalogeras, 2002), but individuals respond faster when presented with stimuli that align with their intended outcome (Ranjan & Srinivasan, 2019). However, the mechanism via which intentions influence later information processing remains elusive. One possibility is that the intention activation itself occurs via valuing/biasing intended features while features that were not selected (unintended choices) being value-neutral (Lewin, 1951; Miller, Galanter, and Pribram, 1960; Wu, 2023). Likewise, previous research suggests that the control of goal-directed behaviour relies on both attentional and inhibitory processes guided by goal-driven attention (Yantis, 1998; Miyake et al., 2000) via enhancement and suppression processes (Chang & Egeth, 2019). The Eriksen flanker task (Eriksen & Eriksen, 1974) provides a unique opportunity to investigate the processes involved in the processing of information (selective attention). The task allows us to check how irrelevant information is suppressed while enhancing relevant information independently. Here, in the pilot study, we investigated how the intentional nature of our action outcomes influences attentional control in an orthogonal task.

Methods

Participants: A-priori sample size calculation for significant two-way interaction with moderate effect size (f = 0.25) and significant mean difference of effect size (d = 0.5) indicated at least 19 participants were required to obtain a statistical power of 0.8, assuming a Type I error probability of 0.05. Considering exclusion factors, 25 volunteers (aged 21 to 28) participated in the study. Stimuli and Apparatus: The experiment was performed on a standard IBM-PC with a 100Hz refresh rate, created using PsychoPy 2023.1.3 (Peirce et al., 2019), while participants were seated at a distance of 80 cm and responded using a standard keyboard. The stimuli consisted of colored arrows of size 0.9º presented on a gray background. There were four kinds of stimuli: base(> or <), neutral (-- < --), incongruent (>><>>), and congruent (>>>>>). The stimuli were presented in three distinct colors, blue, brown, and green, depending on the condition (all arrows were of the same color). The central target was presented at the fixation, and the flankers were presented at an eccentricity of ±1.2º and ±2.2º on either side of the central fixation. Design and Procedure: We operationalized intentions in terms of the outcome that the participant wanted by producing the action that allowed its realization. In every trial, participants were asked to intend a color out of the two given options, selected with the help of a mouse click on the relevant color. They were instructed to try to choose all the colors and color positions equally and randomly. Flanker stimuli followed this in intended (selected choice), unintended (unselected choice), or a third neutral (not in the choice options) color. Each participant completed 360 trials (consisting of 4 flanker conditions [base, neutral, congruent, incongruent] x 3 choice outcome conditions [intended, other, unintended] x 30 replications) after a 40-trial practice round. All conditions were presented an equal number of times. Additionally, we included catch trials where, after the flanker task, the participant was asked whether the color of the arrows matched their intention or not. There were 25% catch trials in the practice session, while the main session had 10% catch trials. A choice monitor screen, feedback conveying their choice ratios for three colors, was presented before every trial to ensure that they formed intentions rightly.

Results

Accuracy results: The accuracy data was fed to 3x4 repeated measures ANOVA. There was a significant main effect of flanker manipulation with lower accuracy for the incongruent condition compared to other conditions, $F(3, 57) = 22.48$, $p<0.001$, $np2 = 0.54$. The main effect of intention, $F(2, 38) = 2.56$, $p = 0.09$, $np2 = 0.11$, and interaction effect, $F(6, 114) = 0.56$, $p = 0.47$, $np2 = 0.02$, were not significant. Mean RT Analysis: A 3x4 repeated measures ANOVA was performed on mean RT values for correct trials. There was a significant main effect of flanker manipulation, $F(3, 57) = 47.49$, $p<0.001$, $np2 = 0.71$. Paired comparisons with Holm's correction showed a significant difference between the base (286.72ms) and incongruent (340.88ms), $t(19) = 6.3$, $p<0.001$, $d = 0.8$; neutral (279.26ms) and incongruent, $t(19) = 8.8$, $p<0.001$, $d = 0.97$; congruent (274.97ms) and incongruent, $t(19) = 8.7$, $p<0.001$, $d = 1.02$; while no significant difference between base, neutral, congruent conditions. There was also a significant main effect of outcome manipulation, $F(2, 38) = 17.44$, $p<0.001$, $np2 = 0.47$. Paired comparisons with Holm's correction showed a significant difference between intended (282.56ms), unintended (306.69ms), $t(19) = 5.6$, $p<0.001$, $d = 0.35$; intended and other (297.13ms), $t(19) = 3.9$, $p = 0.0017$, $d = 0.23$; and other and unintended, $t(19) = 2.1$, $p = 0.041$, $d = 0.14$; conditions. The interaction effect was not significant, $F (6, 114) = 0.95$, $p = 0.41$, $np2 = 0.04$. Although the interaction was not statistically significant, the trend suggests that intended outcomes facilitate response in comparison to unintended and neutral outcomes. This difference increases when more information in the stimuli is presented in the intended color. Interestingly, in the incongruent condition, the valuing of intended outcomes interferes with the suppression of flankers.

Discussion

According to the dynamic hierarchical model, intentions serve heterogeneous functions, such as initiating the intended action, guiding its transition, and monitoring its outcomes (Pacherie, 2006). Our results align with such a framework where setting precedence for the information relevant to the intended action is one of the functional obligations. The activation of intentions does not end with the execution of the action. Instead, it remains activated, influencing the subsequent processing of stimuli. Our results suggest that intended features, due to their positive bias/valence, play a role in the enhancement of selected information with faster activation process. Since both the target and the flankers shared the same color, intended features could be interfering with the distractor suppression and thus playing a farther role in the inhibitory control required for the conflict resolution. Further studies are required to dissociate between the two mechanisms that we observed in our study.

**Intentional Binding and Action-Effect Monitoring**

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It has been shown that a stimulus perceived as the consequence of one's own action (action -effects) is processed differently (Hughes et al., 2013.; Kumar et al., 2015), as compared with stimuli that are not action-effects. Action-effects are understood to be perceptually bound to the action that caused it, causing lower detection thresholds (Hughes et al.,2013). This is called intentional binding. Ideomotor theory, pre-activation accounts and forward action models provide plausible explanations for this phenomenon. Similarly, acquiring action-effect associations has been suggested to be independent of conscious perception as well as the task relevance of the actions and the effects (Hommel et al., 2003; Kunde, 2004). The ideomotor theory of action holds that the formation of action-effect associations occurs before the performance of the outcome eliciting action, meaning that the acquisition occurs automatically (Elsner & Hommel, 2001; Kumar et al., 2015). Following these findings, Kumar. et al. (2015) showed that task-irrelevant feature singleton capture attention when they appear followed by an action as compared to when they appear automatically. More importantly, they also showed that attention captured by a singleton that is perceived as an action-effect is mediated by the action-effect contingency. That is, does attention capture occur as long as a singleton follows action or should there be a consistent relationship between action and the occurrence of a singleton? They showed no capture when the singleton appeared only in 50 percent of the action trials. The findings suggest that action effect contingency is more important for attention capture than simply the presence or absence of action prior to stimulus presentation (Kumar et al., 2015).

In the present study, we aim to further explore the action-effect associations following action-contingency manipulation. Action effect contingency is established in two ways - first, the effect consistently follows the action; two the effect is present when action is not. In Kumar et.al. (2015), action-effect contingency was established based on the first principle. In the present study we manipulate action effect contingency based on the second principle. That is, the effect is present whether or not an action preceded stimulus presentation. If attention-capture is solely driven by action effect contingency, then we should observe absence of attention capture in the action as well as no-action conditions, as in Kumar et.al. (2015). However, if the probabilities of singleton presence is important, then this would not be the case. We randomized the action and no action conditions to see if it caused any change in the findings by Kumar et. al (2015). This study is essential, because now, the effect will be present without the cause in half of the trials in random order. Will this impact the association of the presumed action effect? If so, then what would be the result? Preliminary data from 7 participants (N=7), who were naive to the motivation of the study, participated in the study (mean age: 20.6). The experiment was conducted at IIT Gandhinagar, in the Psychophysics Lab. Matlab version 2021b was used and the experiment was run on psychtoolbox. The experiment consisted of 432 trials, where action and no-action conditions were randomized. The trial begins with a fixation mark, either a '+' or an '0'. After 500ms, a set of 6 or 12 placeholders will appear at the center of the screen. Depending on the type of fixation mark at the beginning, participants either press the spacebar (action condition) or just wait for the search display that appears in 250 ms (no-action condition.). The time taken for the keypress in action condition was not accounted for, nor were any repercussions for taking a longer time. In further study, this will be accounted for and longer trials will be aborted. Right after pressing the spacebar (action condition), the search display appears. The search display will consist of either 6 or 12 random numbers from 2 to 9. The target is either 5 or 2. Participants press the left or right arrow keys to record their responses (counterbalanced). A representative image of the experimental design Overall, four factors are manipulated in 2 different levels: set size – 6 and 12; action cued by fixation mark– action , no action; target identity– 2 or 5; and then finally, target motion– where a singleton that moves in all trials will coincide with the target every 1/6 or 1/12 times depending on the display size 6 and 12 respectively. Reaction times of participants were analyzed individually, and outliers (2.5*SD + or - mean) and error responses were removed using the software R. Trials with RTs above 2500 ms and below 450 ms were removed from the final analysis. This analysis was done based on the study by Neeraj et.al (2015).

The preliminary data showed faster processing for no-action conditions, where the target is the singleton. Perhaps, this could be a prediction error in terms of the effect being present without the action. Moreover, due to the high variability in the data, we looked into the change in the pattern of response selection over time across trials. It showed attention capture for action-singleton conditions in the first fifty trials, after which the action is not processed as a reliable predictor of the singletons. These findings pose several questions. Would action-singleton trials after the first 50 trials reset the association back? Would trials immediately after the action-singleton conditions, where action is followed by no-singleton targets incur a cost? If we reduce the overall uncertainty in the singleton by fixing its position on the search display, can we clearly observe the pattern of processing the singleton? These questions can be looked into once we add more data to this preliminary study.

**Repeatability and plasticity of decoy effect in Zebrafish (*Danio rerio*)**

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Consistency in choices with an increase or decrease in the choice set indicates an absolute valuation mechanism of options, crucial to upholding economic rationality. Animals are widely known to violate such normative principles of rational decision-making, however, the neural mechanism is poorly understood. Interindividual differences in performing such cognitive tasks provide an opportunity to investigate its mechanistic and developmental aspects. Studies in non-human animals have established behavioural types also known as personalities as predictors of such inter-individual differences in cognitive performance. Here we use zebrafish a neurobiological model system amenable to behavioral, genetic, and pharmacological tools to test the normative principle of independence of irrelevant alternatives with a perspective of interindividual differences. We test the hypothesis that personality types are categorized based on a battery of behavioural tests and movement parameters can predict the measure of rationality. We infer the shoaling preferences from the spatial trajectories of freely swimming zebrafish individual zebrafish in an arena where they could observe and engage in shoaling behaviour near conspecific zebrafish in nearby display tanks in binary and ternary choice sets. We successfully demonstrated the replicability of behavioural traits related to boldness and movement parameters. Currently, we are in the process of analyzing the data pertaining to rationality.

**Sex-based difference in rational decision making in zebrafish (Danio rerio)**

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Normative principles of economic rationality assume that a rational individual makes consistent choices that maximize utility. The principle of independence of irrelevant alternatives (IIA) proposes the invariance of preference order between two options, regardless of the inclusion of other alternatives, or decoys, in the choice set. Organisms ranging from slime molds to human beings are reported to have violated IIA in various tasks, mostly with respect to combinations of two or more choice attributes. Here we investigate the decoy effect in zebrafish across a single dimension of shoal size, exploring decoy options using a pair of combinations of dichotomous and trichotomous shoal size choices. A single focal fish freely moved in an arena with only visual information from shoaling conspecifics placed in display tanks surrounding the arena, with the randomized placement of various fish shoal sizes in the display tanks. The shoal choice preference was inferred from time spent in the respective sectors facing the display tanks, using the focal fish's trajectory data. We show sex-based differences in rational decision-making in the social choice task, where only males violate rationality. Males show a shift in relative preference for the larger shoal while females tend to keep the relative preference constant even with the decoy option. Male individuals exhibit a change in their relative preference towards the larger shoal, whereas female individuals tend to maintain a consistent relative preference, even when presented with a decoy option. The results are consistent with previous reports of finding sex-based differences in the social preference of zebrafish. However, the study also provides the first report of a deviation from rationality with respect to IIA within a single dimension of social choice attributes in any neurobiological model.

**Influence of Experts' Domain-specific Knowledge on Risk Taking in Adversarial Situations under Time Pressure**

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The decisions & policies made by Experts in high-risk operations, for example, healthcare and the military, have far-reaching consequences for the general public. Sometimes these decisions must be made in adversarial situations and under time pressure. Therefore, it is essential to understand the quality of decisions under these scenarios holistically. However, the influence of expertise on risk-taking in adversarial situations has received little attention & there is a need to understand how experts evaluate risk and set their attitude toward potential losses (Chassy & Gobet, 2020). Risk-taking in adversarial situations results from a complex set of factors – Time pressure being one of the crucial factors. While there are many studies of risk-taking behavior in economics, using lottery games, etc., in these studies, the uncertainty seems to come from the stochastic environment in contrast to an adversary's choice, which is more controllable & thus closer to the naturalistic environment. Holdaway & Vul (2021) observe: "The combination of objective world state evaluations, reliable player competency measures, and massive amounts of available data make chess a tractable yet complex research vehicle." Prior research has identified Chess as a lens through which adversarial situations can be studied effectively. Recently (Holdaway & Vul, 2021) evaluated Risk-taking in adversarial games using an online chess database. Nevertheless, none of the studies have comprehensively assessed the impact of time pressure in these adversarial situations using a large sample size. Some surprising findings from the above studies using chess as experimental Paradigm are: 1. Risk-taking is moderated by skill level. 2. Experts vary their strategies depending on the opponent's skill level. 3. Risk-taking behavior changes depending on past mistakes – and is more pronounced after mistakes or gains.

Methods:

Our work attempts to extend the research (Holdaway & Vul, 2021) & (Chassy & Gobet, 2020) using a similar methodology to understand the influence of Time pressure on risk-taking when faced with opponents of varied expertise: Amateur, Club players, Candidate-Master, and Master. We focus our research on the Master level (Playing strength of Elo of 2000 – 2200). Our work differs from previous research that utilized tournament games with the added incentive of prize money. In contrast, the open-source games we have chosen for our study offer only rating gains as a reward or incentive. We evaluate the games from the open source lichess.org database. This database is the world's largest database, with more than a billion games. We restricted our analysis to only the Master level as the player in the current study against opponents ranging from amateurs to masters. We use the criteria described by Chassy & Gobet(2020) to define risk-taking strategies as moves that lead to more winning games while increasing the probability of losses. For example, Figure 1 depicts the percentage of risk-taking strategies used by the player against opponents under varying time pressures: Time available High (30 minutes), Time available Medium (15 minutes), and Time available low (5 minutes) for the entire game.
Players were assigned to one of four groups: amateurs (1600-1799 Elo), club players (1800-1999 Elo), candidate masters (2000-2199 Elo) & Masters (2200 to 2399). In our study, Masters level expertise is classified as Experts.
Hypothesis: H1: There is an influence of the Time pressure on the risk-taking behavior of Experts in adversarial conditions against opponents of various expertise levels. 1. Rating difference: Delta = Elosecond – Elofirst ( 1) 2. Probability of Winning of the first player = p= (1+10 Delta/400) -1 ( 2) 3. Risk-taking is operationalized as standard deviation (σ) around the expected value (μ) (Chassy & Gobet, 2020)

Results:

Chi-squared goodness of fit test was used to test whether strategies used by Experts under different time pressures differ based on the opponent's skill level: i.e., when faced with other experts or amateurs. The results demonstrate that Time pressure influences the player's strategies (risk-taking behavior of an expert) depending on whether the opponent is an amateur or an expert(master). $X2(2, N= 21768)$, $p < .05$, Cramer's $V = 0.021$). Work is underway to increase the sample size and re-evaluate the results with the procedure described in (Holdaway & Vul, 2021), which uses the standard deviation of the expected result as an indicator of risk - instead of just the pre-determined first moves to determine the risk - as per the procedure described by (Chassy & Gobet, 2020).

Discussion

The results demonstrate that Time pressure influences the player's strategies (risk-taking behavior of expert) depending on whether the opponent is an amateur or an expert(master). We plan to extend the experiment using fine-grained skill levels of players from novice to expert and model the observations using existing cognitive modeling frameworks.
Work is underway to re-evaluate the results by following the procedure described by (Holdaway & Vul, 2021), which is more robust in determining risky strategies by evaluating each state against a benchmark computer engine. We also plan to test the influence of Time pressure on System 1 and System 2 processes, as these can be operationalized in chess.

## De-obfuscating Context Effects in DecisionMaking

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One of the most widely studied phenomena in decision-making is the 'attraction effect' or 'asymmetric dominance effect.' In addition to the ubiquitous presence of the standard attraction effect across domains, many researchers have also shown the absence or reversals of the effect under varying conditions, contributing to various boundary conditions for the effect. (Huber et al., 2014) have listed various boundary conditions for the effect and suggested manipulation checks in future experiments. That list includes prior trade-offs and cross-respondent value heterogeneity as two separate drivers inhibiting the attraction effect. However, we argue that heterogeneity across respondents directly results from prior trade-offs. Prior trade-offs are individual biased preferences for one of the choices in the binary choice set. (Huber et al., 2014) also list logical reasons for prior trade-offs inhibiting the attraction effect. Nevertheless, until now, none has provided a rigorous mathematical analysis for the cause and effect of this baseline asymmetry of shares. Via two different model-agnostic simulations of Subjective Indifference Curves (SICs), we show the cause of the baseline asymmetry and depict its effects: potential misses and false alarms (FAs) in reporting the context effects. Before that, we discuss context effects as violations of the rational choice theories and various measures used in the literature to capture the effects.

The Context Effects

Rational choice rules

Independence from irrelevant alternative (IIA): According to the rational choice rule of strong IIA, the ratio of choice shares of two items should remain constant irrespective of the context (choice set) in which they are presented, i.e., P(X|C)/P(Y|C) = Constant irrespective of C; where X and Y are two items and C is any context.

Stochastic Transitivity (ST): ST, a weaker form of IIA holds if the preference order for two items remains same across contexts. In other words, ST holds when the following property is satisfied. If P(X|C1) > P(Y|C1), then P(X|C2) > P(Y|C2), where X, Y are two items and C1, C2 are two contexts.

Regularity: According to 'regularity', another weaker form of IIA, probability of choosing an item from a set cannot be increased by adding another item to the set. Formally, $\forall\ x \in C1 \subseteq C2$, P(x|C1) >= P(x|C2)

Context effects as violations of the rational choice rules

As a violation of ST, a weak IIA, similarity effect (Tversky, 1972) predicted that if items A and S are placed close to each other on the attribute space such that both are perceived to be similar, choice share of B increases, P(B|{A,B,S}) > P(B|{A,B}).

Suppose, two items A & B are on the indifference curve in the attribute space, and a third item D inferior to B is introduced in the set. If clear dominance relationship is perceived between B & D such that D is dominated by B but not by A, choice share of B increases from the binary set to the ternary set. P(B|{A,B,D}) > P(B|{A,B}). This is called asymmetric dominance or attraction effect (Huber et al., 1982). This effect was an empirical illustration of the violation of the principle of regularity.

Measures of context effects

Traditionally, context effects had been demonstrated and quantified in a pair-triplet experimental design where the subjects give their baseline preference in a binary choice set (a pair) followed by their preference in a ternary choice set (the triplet). And the strength of the attraction effect in this case was expressed in terms of change in probability of shares. If {A,B} is the binary set and {A,B,D} is the ternary set, $\Delta P$a = P(A|{A,B,Da}) – P(A|{A,B}), where Da is a decoy option targeting A.

To enhance effect size and hence statistical power of the studies, (Wedell, 1991) introduced a triplet-triplet design, where the focal options A & B were introduced with a decoy favoring one in one context and with another decoy favoring the other option in the next context, i.e. {A,B,Da} and {A,B,Db}, where Da and Db are the decoys favoring A and B respectively in the two contexts. In this triplet-triplet design, Wedell claimed, there was a double opportunity to detect the effects. Subsequently, most of the context effect studies have used this triplet-triplet design.

One measure of the effect in such a design, as used by (Wedell 1991) and others (Liu and Trueblood 2023), is given below, by calculating the difference in choice shares between the two contexts as measured from the respective choice frequencies: $\Delta P$a = $P$(A|{A, B , $D$a}) − $P$(A|{A, B , $D$b}), $\Delta P$b = $P$(B|{A, B , $D$b}) − $P$(B|{A, B , $D$a}),where $\Delta P$target > 0 means an attraction effect and $\Delta P$target < 0, a reversed attraction effect. More popular measures of context effects include Relative Share of Target (RST) (Berkowitsch et al., 2014) and a revised version, RST* (RSTew in (Katsimpokis et al., 2022)). Although the triplet-triplet design was deemed to be a test of menu-dependence alone (Huber et al., 2014), (Katsimpokis et al., 2022) showed that even a triplet-triplet design can be used to indirectly test the violation of regularity principle and they introduced Absolute Share of Target (AST) and Absolute Share of Competitor (ASC) as the required measures.

We suggest that the proximate cause of the baseline asymmetry of shares is that the experimenter-defined indifference curve (EDIC) differs from the subjective indifference curves (SICs). Hence, the target and competitor, as defined by the experimenter, may not lie on the proper indifference curve, and the relative placement of the decoys could differ for subjects as well as in the two contexts for the same subjects in the triplet-triplet design.

The Hypothesized Effects

We hypothesized that if SICs differ from the EDIC, in the triplet-triplet design, the two contexts' decoy placements on the attribute space will no longer be symmetrical to the true SICs.

This will lead to some of the measures giving FAs, i.e., they may indicate context effects even in the absence of one. Also, for the same reason, the strategy used by Wedell to increase the measured effect size might work against the intended goal and could obfuscate the effects, uncaptured by even AST and ASC. Due to the unsymmetric placements of the decoys, one context may show an attraction effect while the other might show a reversed attraction effect, which, when combined, can mute the overall effect. We call these 'misses' in detecting context effects. Using two simulations, we tested these hypotheses.

Simulation Methodology

Items in the choice set were represented as points on the x-y plane. And the x-y plane represented the attribute space with the two primary attributes of interest representing x and y axis. Two items A, B from the binary choice set are placed on the attribute space as two points and we call the line joining them, i.e. AB as the EDIC. SICs representing different individuals are lines with varying slopes. Deviation from the SIC is characterized by a signed-perpendicular distance. The signed deviations from the SIC serve as arguments to a SoftMax function that generates choice shares in terms of probabilities summing to one. The left panel in Figure 2 shows line AB as the EDIC with the perpendicular line segments BB' representing the signed deviation of B from the B' points on respective SICs. The right panel in Figure 2 shows the simulated baseline choice shares in the binary choice set as a function of SIC slopes.

We used two simulations, a 'model-agnostic and theory-agnostic simulation' and a 'model-agnostic but theory-included simulation' to test our hypotheses. By model-agnostic we mean that the simulations do not include any of the models for context effects, though they follow rational choice rule, IIA. For both the simulations, the items A and B are presented either in pairs or in two triplets in the triplet-triplet design. The second simulation incorporated the theories of attraction and similarity effects as observed from empirical studies, thus violating IIA in a small region. We used a Temperature-Scaled SoftMax function in this simulation to model these two theories. We also modeled the theory that if an attraction decoy fails to establish the perceived dominance of the target, it appears similar to the target, and thereby, produces a similarity-driven reversed attraction effect (Spektor et al., 2021). For SICs in a certain range, close to EDIC, when the conditions of the above theories were satisfied, both the context effect theories themselves were modeled by scaling the beta value of the temperature-scaled Softmax function by a factor of 5, which was 1 otherwise.

Results

The left plot in Figure 3, shows the results from the first simulation and the right plot shows that from the second simulation. From the first simulation, we can see that, even in the absence of any violation of IIA principle, some of the measures of context effects (RST and $\Delta P$) show negative effects, resulting in FAs. In the second plot, note that there are few points corresponding to SIC slope values around '-1' (i.e. the EDIC slope here) representing choice shares of A & B in triplets whose values are clearly beyond their corresponding baseline values. These are cases of violations of regularity, but none of the measures of context effects, including AST and ASC capture them.

Discussion

It should be noted that the FAs shown in the simulation constitute mostly reversed effects. It means, taken together, both FAs and Misses depict a systematic undervaluation of the standard attraction effect. We propose two general guidelines to obviate the issues in future studies:

1. Incorporating pair-triplet measurements wherever possible in the experimental design so that the experimenter can
a. access context-based preference reversals calculated directly from pair-triplet designs and
b. infer SICs indirectly.
2. Accessing SICs by implementing conjoint analysis or staircase methods in the preferential domain and perceptual domains respectively.

Conclusion

In summary, we show, via our simulations, that although the triplet-triplet design has been extensively used in the literature as a convenient way to capture the context effects, if SICs differ from the EDIC, there can be FAs and misses in detection of context effects using the existing measures, thereby, undervaluing the standard attraction effect. Both these FAs and misses could result simply from the fact that the two decoys placed on the attribute space are no longer symmetrical to the true indifference curve. As solutions to the issues, we propose to include pair-triplet measurement in the experimental designs or to access the SICs using conjoint analysis.

## Magnitude-Dependent Loss Aversion in Risky Choices

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Prospect Theory (Kahneman & Tversky, 1979) is arguably one of the most influential descriptive theories of choice, which consists of a value function that predicts the overweighting of losses compared to gains. The theory came in the wake of empirical findings that showed people reject choices involving potential gains versus losses of small amounts that could not be explained by risk aversion. Additionally, people also judge the affective judgment of losses to be more impactful than that of comparable gains. This was explained using loss aversion, with the dominant idea being that losses loom larger than gains for both risky and riskless choices (Tversky & Kahneman, 1991). A series of studies found that loss aversion is magnitude-dependent for judgments (e.g., Mukherjee et al., 2017), even when scales appropriate to measure loss aversion are used. It can also disappear for choices based on a range of values (Walasek & Stewart, 2015; Zeif et al., 2022), leading one to speculate about the generalizability of loss aversion (Gal & Rucker, 2018). This has given rise to three positions in the field: the classic version in favor of loss aversion, the evidence against the existence of loss aversion, and a magnitude-dependent version that suggests loss aversion exists for large magnitudes but not for small magnitudes.
This study aims to provide empirical evidence to address the debate. Furthermore, as elicitation modes might impact choices and preferences (Slovic, 1995), three different standardized measures of loss aversion for risky choices, following the classical paradigm, were employed.

Experiment 1: Binary choices

Data were collected from individuals not affiliated with formal educational institutions (n = 93, mean age 29.7 years; % of males = 24). The analysis was conducted only on completed responses (n = 80). Participants were asked to partake in a hypothetical choice to indicate whether they would accept or reject a game consisting of eight rounds of equiprobable symmetrical gambles of a specific magnitude (5INR, 10INR, 25INR, 50INR, 75INR, 100INR, 250INR, 500INR; presented in a random manner). For example, a 50% chance of +25INR and a 50% chance of -25INR. Participants completed the task involving choices first and then were also asked on a separate page to think about how much effect gaining versus losing would have on their feelings for each of the eight rounds. A logistic regression showed that magnitudes predicted choices (Estimate= -0.0029, $z = 5.24$, $p < 0.001$). Additionally, magnitudes also predict affective judgments (Estimate= -0.0006, $t = 3.081$, $p < 0.001$). We conducted a replication on the student population (n = 117). Similar to the previous results, magnitudes predicted choices (Estimate= -0.0036, $z = 8.16$, $p < 0.001$) and affective judgment (Estimate= -0.0006, $t = 3.60$, $p < 0.001$), supporting magnitude-dependent loss aversion.

Experiment 2: List Method

UG students from Indian universities participated (n = 160, mean age 19.3, SD = 1.50, % males =65 ) in a classroom setting using pen and paper. Participants engaged in six rounds of gambles with a 50% chance of winning a fixed amount and a 50% chance of incurring varying losses. In the low-magnitude group, choices comprised a fixed gain of 25 INR and varying losses from -5 to -30 INR in 5 INR increments. In the high-magnitude group, choices involved a fixed gain of 250 INR and varying losses from -50 to -300 INR in 50 INR increments. Participants marked Accept or Reject in each round.
A total of 20% of participants were excluded based on criteria following Mrkva et al. (2020), resulting in a final analysis of 128 participants. The loss aversion coefficient (Lambda, λ) was computed by dividing the fixed gain by the smallest loss where participants began rejecting gambles. Results revealed lower loss aversion for the low-magnitude group (mean $\lambda = 1.20$, sd = 0.2) compared to the high-magnitude group (mean $\lambda = 1.47$, sd = 0.52); $t(126) = 3.5$, $p < 0.01$, Cohen's $d = 0.7$. These findings further support magnitude-dependent version loss aversion.

Experiment 3: Binary choices in a sample space

Data was collected from UG students enrolled in an engineering degree at an Indian university (n = 208, mean age = 19.19 years, SD =0.91, % males =79.3). Participants were asked to imagine receiving ₹500 as token money to start the game. Each participant completed 200 computer-based trials of an equiprobable gamble. The values were drawn from a range of 10 gains and 10 losses, resulting in 100 trials that were repeated to counterbalance the gain/loss position on the screen. The task was to accept/reject each of those gambles by pressing a specified key. There was no time limit for the response window. For the low-magnitude group (n =100), magnitudes of gains and losses ranged from ₹5-₹50 in ₹5 increments, while for the high-magnitude group (n =108 ), magnitudes ranged from ₹50-₹500 in ₹50 increments.
Logistic regression was computed to calculate the loss aversion parameter lambda (λ) for each participant. The median loss aversion (λ) co-efficient was 1.1 (sd = 0.2) for the low-magnitude group and 1.32 (sd =0.1) for the high-magnitude group, resulting in a significant difference ($t (178.38) = -5.5$; $p<0.001$, $d = .14$). The findings offer support for magnitude-dependent hypotheses based on two measures of loss aversion: risk-taking for the lottery and the loss aversion coefficient across populations and experimental settings. While this study employs hypothetical lotteries, earlier research has revealed similar risk-taking behavior in both incentivized and non-incentivized settings (Camerer, 1989; Kachelmeier & Shehata, 1992). Overall, the results highlight the importance of magnitude in developing our understanding of loss aversion.

## Hidden Latent Inversion and Updating of Unselected Actions

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Introduction

Our choices are often shaped by comparisons, influencing our preferences. Imagine moving to a new city with limited information about its layout, traffic, and rush hours, and having to choose your daily commute. Suppose you randomly select one route and find that it gets you to your destination on time. Will you choose the same route the next time? Research has shown that choosing an option not only increases its value but also diminishes the value of unchosen alternatives (Festinger (1964)). This update in values after a choice impacts subsequent decisions. Several explanations have been proposed for this phenomenon. One possibility is that unchosen actions continue to occupy our thoughts even after a decision is made, as memory traces generated during decision-making persist and influence our thinking (Roese (1997); Schwartz (2004)). Alternatively, when memory links two distinct representations together, updating the value of one representation triggers an update in the associated second representation (Shohamy & Wagner (2008); Schuck & Niv (2019)). This suggests that adjustments may occur in the values associated with the second representation when feedback for the first representation is presented. Biderman and Sohamy (2021) argue that unchosen actions are updated inversely to the feedback of chosen actions, meaning, if a chosen action is rewarded, the value of the unchosen action is reduced. Hence, assigning a value to a chosen action may also reinforce the decision to avoid selecting alternative options (Ben-Artzi, Kessler, Nicenboim, & Shahar (2022)). In the first experiment reported by Ben-Artzi et al (2022), a Bayesian regression model was employed. They show that the tendency to choose a card in consecutive trials depends on the reward received previously on the chosen card. If a card was not chosen on trial n and the choice was still rewarded, then the tendency to choose that unchosen card on the following trial, n+1, decreases. In their second experiment where they modeled choices with five distinct reinforcement learning models revealed that individuals consistently compared the values of all available options. Notably, they report that the 'avoidance learning' model seemed to capture this choice behavior. In this study, our aim was to replicate the results reported by Ben-Artzi et al. (2022) using the same methods to validate their findings. Subsequently, we extended the work from a two-raffle multi-armed bandit to a multi-raffle multi-armed bandit task.

Methods

Fifty participants (10 females; mean age ≈ 22) completed the multi-armed bandit experiment, which comprised four blocks of fifty trials each. Each block could be positive or negative, and block presentation was counterbalanced. A trial involved selecting one of two cards from four fixed options. In positive blocks, the outcome could be +1 or 0, while in negative blocks, it could be 0 or -1. Participants were told to maximize their profit by choosing a card they think was rewarding.

We used four distinct RL models, each with a unique approach to updating the action value of the unchosen option: 1. Baseline model: Only the chosen option was updated based on a reward prediction error. 2. Single prediction error model: A portion of the prediction error was inverted and assigned to the unchosen option. 3. Double updating with two prediction errors model: Individuals underwent a latent prediction error for the unchosen option. 4. Avoidance learning model: Individuals held different perceptions when choosing or avoiding a card. Model Comparison: We evaluated the models by comparing their expected log-probability densities (elpd) using the loo-compare function from the loo package in R. The winning model was determined based on elpd values.

Results

Our experimental results using a Hierarchical Bayesian Logistic Regression (posterior median = -0.36, HDI95% = -0.50 to -0.21) aligned with the original paper's findings. Specifically, the previous outcome for the chosen card in trial n predicted the tendency to choose an unchosen card in trial n+1. Contrary to the original paper's claim that Model 1, which updated only the chosen option, produced results opposite to other models, our findings did not support this claim. While Ben-Artzi et al (2022) designated Model 4 as the winning model, which distinguishes between perceptions of choosing and avoiding a card, our computational results favored Model 3 which incorporates the inversion of outcome history and presumes a latent prediction error, outperforming other models.

Discussion

Previous studies have highlighted that the probability of selecting a consecutively unchosen option can be influenced by the persistence of unchosen alternatives in our thoughts, the devaluation of the unselected option, and the inverse relationship between the outcome of the previous trial and the unchosen option. Our findings suggest that the model which incorporates the inversion of outcome history and presumes a latent prediction error is a more likely explanation for this effect. Unlike previous studies that demonstrated the prevalence of avoidance, our findings indicate the prevalence of inversion in the consecutive choice. This diversity in results underscores the presence of multiple underlying factors that warrant further exploration, providing valuable insights into decision-making processes. In a planned follow-up, we aim to

expand upon our current findings and enhance the robustness of our conclusions. We plan to extend our investigations to scenarios involving more than two raffles. This decision is motivated by the desire to explore how our winning model performs in more complex decision-making contexts, gaining a deeper understanding of its strengths and limitations.

# Impact of Loss-Framing and Risk Attitudes on Insurance Purchase: Insights from a Game-like Interface Study

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Introduction

In this study, using choice architecture as a form of risk communication embedded in a game-like visual interface, the effectiveness of nudges by loss-framing and individual risk attitude measures in insurance purchases was studied. The insurance products considered are term-life, health, family health, accident and a pension scheme. Different insurance policies provide different features to participants, such as longevity, premium amount, etc. Examining participants' responses to various insurance alternatives helps to understand the impact of different insurance features on participants' risk transfer mechanism underlying insurance as well as the impact of a nudge to buy insurance. We used loss framing as a nudge to test the willingness to purchase insurance. We also examine the association between risk attitudes (DOSPERT questionnaire) and Willingness to Purchase (WTP) specific insurance.

Methodology

Sample description

Data was collected from three sets of participants: 1.Group A: 97 undergraduate students. The participants were financially dependent on their parents. 2.Group B:- 42 older adults, employed as security guards and administrative staff at the institute with asalary range of INR 20,000 – 30,000 per month. 3.Group C:- 65 participants similar in age range to group B, but for the education levels and a salary in the range of INR 50,000 to 70,000 per month.
The participants' gender was not considered as a factor in the analysis and hence not recorded.

Experimental Design

A web-based game-of-life like application is designed and developed using Vue. The interface presents an individual's typical life stages, from a job as a young adult to retirement. The information is presented in text and audio format in Hindi, English, and Telugu. At each turn, the balance is updated and shown for easy reference based on the frequency and kind of incident. After an automated deduction of premium amounts and a predetermined monthly living expenditure, the monthly savings is presented. The accident and health insurance alternatives are provided twice, pre-post an injury and subsequent hospital charges, to capture the decision change by loss framing.

Results

The younger age group is more likely to acquire practically all insurance products and pension plans. Insurance and pension plans are more acceptable in group B. The influence of income disparities can be seen in the insurance consumption of groups B and C. For the three insurance products (IHI, FHI and AI ) in the older group, the loss framing effect is evident. Individual health insurance is also declining in the younger generation. The difference between before and after loss framing for family health insurance is a 19% rise for younger participants and a 4% increase for older people; ; for accident insurance, the loss framing impact is 6% for younger and 22% for older individuals. The relationship between risk-taking scores and willingness to buy insurance was explored using logistic regression. Only family health insurance and accident insurance following a mishap show a significant connection ($p<0.05$) as a function of risk ratings in group A. Only accident insurance (pre-nudge) had a statistically significant positive link with older participants' risk perceptions (groups B & C). In contrast to the pattern seen for group A, the positive connection shows that as risk-taking grows (or declines), so does insurance usage.

Discussion

Group A exhibited a higher WTP across all insurance categories, which can be attributed to a possible lack of understanding of the risk transfer mechanism (Eling et al. (2021). Group B has a higher WTP than Group C, which means that lower income leads to investments in savings products (whole life and pension) and protection as provided by health/accident insurance. For group B, the impact of loss aversion on insurance demand may interplay with narrow framing and subjective probability (Guttman et al., 2021; Gottlieb & Mitchell, 2020). People with narrow frames have preferences that consider both consumption smoothing and gain-loss utility (Gottlieb & Mitchell, 2020). While consumption smoothing increases insurance demand for risk-averse individuals, a concavity of the gain-loss utility function results in a negative correlation between risk aversion and insurance consumption, which may explain risk aversion's negative correlation with health insurance in particular. For accident insurance, the older demographic group shows a positive correlation value and significance with risk attitude. The findings back up previous research (Charness & Jackson, 2009) that found that increasing responsibility increases risk aversion. The effect of nudge is more substantial in the younger group, which is consistent with the premise that risk-taking people purchase more insurance in the case of a loss (Chetty & Looney, 2006). Another explanation for the decreased nudge effect in older cohorts might be financial responsibilities, which could outweigh the nudge effect.

# Uncovering the mechanisms underlying approach avoidance bias in anxious individuals

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## 1 Introduction

Anxiety disorders characterize persistent worrying, avoidance behaviors and restlessness that disrupt daily life. The 2019 Global Burden of Diseases reports Depression and Anxiety as the most disabling mental disorders worldwide, with over 500 million cases [1]. While trait vulnerability and chronic stress may trigger the onset of these conditions, the exact neurobiological mechanisms are still not fully understood [2]. Current studies suggest that anxiety and stress impact neural circuits linked to motivation, learning, and reward processing [3]. These effects are evident in behaviors like excessive avoidance and overgeneralized anxious states [4]. Imbalance in approach vs avoidance and higher punishment sensitivity leads to greater pavlovian conflict in anxious individuals, which is thought to contribute to suboptimal decision-making and reinforce the psychopathology [5] [6]. Conflict resolution is mediated by cognitive control processes to optimize behavior based on goal-relevant information by either optimally biasing attention to task or inhibiting inappropriate responses thus overriding conflict. Evidence suggests impaired inhibitory control and negatively biased attention in anxious individuals [7]. Whereas studies involving reversal of reward, punishment-outcome association in a periodic fashion have tested learning of contingencies amongst participants wherein anxious individuals have shown poor learning performance perhaps because of reduced sensitivity to feedback [8]. However, the relationship amongst these different features of anxiety like reward-punishment conflict, avoidance bias, reversal and cognitive control are not well understood due to lack of a paradigm that incorporates all features into a common framework, and studied in the same individuals [6]. To address this gap we designed a simple, ecologically valid task based on approach-avoidance that incorporates pavlovian conflict, reversal learning and cognitive control into a common framework. For example, in our paradigm, the choices elicit an instrumental-Pavlovian conflict: while the approach behavior leads to rewards encouraging the instrumental response, it may also result in a shock (punishment) which promotes Pavlovian avoidance response. To ensure optimal task performance, cognitive control mechanisms need to be recruited to override the Pavlovian conflict and promote goal-directed actions (Figure 1). Furthermore, the task also offers insights into how avoidance bias is reinforced through feedback which becomes important especially after reversals. Finally, by utilizing computational models of decision making in conjunction with the task, we intend to identify and parametrize mechanisms leading to avoidance behavior in subclinical anxiety.

## 2 Methods

Participants were presented with one of three types of stimulus: green , blue or red colored trees. Each with different magnitudes of reward and punishment thus varying degrees of conflict: green (no conflict), blue (low conflict) and red (high conflict). We designated conflict levels depending on reward, punishment values and intensity of shock (Table 1).

No conflict trees: Only reward (1-10 points), No punishment

Low conflict trees: Reward (11-20) : Punishment (-1 to -10) [2:1] + 3-point rated shock

High conflict: Reward ( 21-30) : Punishment (-11 to -20) [3:2] + 4-point rated shock

We tested sensitivity of shock for each participant on a 5-point Lickert scale, where, 1 corresponds to barely perceptible shock to 5 corresponding to painful sensation of shock. We incorporated 3-point and 4-point (which corresponds to not yet/slightly irritating and highly irritating sensation of shock ) to low and high conflict trees. The game has 4 block designs aka terrains which differ in availability of no conflict/ high conflict options and punishment regime (Table 1 & Figure 2). Terrain II to III transition includes reversal of contingencies. Terrain I & II should reveal inherent Pavlovian biases, while Terrain III assesses feedback sensitivity to reversal, and Terrain IV gauges cognitive control amid elevated Pavlovian conflict. Participants can choose to approach (harvest) or avoid (skip) at each trial. The objective of the game is to maximize reward. On harvesting they either get a reward (fruits) or shock as punishment (thorns) defined by probability in the punishment regime while on skipping they move on to the next trial. The game duration is 20 mins with 5 mins each terrain. (Figure 2). Participants were given 1 minute of trial round before the 20 mins game started. That includes 15-20 trials to figure out contingencies of terrain 1, rest they need to learn as the environment changes incrementally.

While a number of standard questionnaires like GAD7, PHQ9, STAI-State, STAI-Trait, IUS-12, BIS-11 were recorded from participants. In the current analysis, we have only looked at STA-Trait scores as a measure of Trait anxiety in the participants. The first experimental data collection as pilot study included 27 participants (11F, 16M) (n= 3 excluded from analysis). The results are based on pilot data of 24 participants. Participants were grouped into low or high trait anxiety (median split, STAI-T = 43).

## 3 Results

First, we asked if conflict affects approach-avoidance decisions in high trait anxious individuals? We hypothesized increased avoidance tendencies in high trait anxious individuals with high-conflict choices. Correlation between % approach and trait anxiety scores revealed a weak trend towards greater avoidance in high trait anxious individuals in terrain-I, but it wasn't significant. In terrain-II, as high-conflict options increased and no-conflict options decreased, there

was a general decrease in approach (Meanap: TI= 87.6 > TII= 81.6) but the correlation remained not significant.
We also examined avoidance across different conflict levels (No, Low, and High) in all four terrains (Figure 3). The mean % approach decreases with conflict (No Conflict > Low Conflict > High Conflict) in the high trait anxious group. Whereas low trait anxious individuals showed higher approach, particularly for High Conflict decisions in terrain I & II (Figure 3a, b). These results indicate an avoidance bias in the high trait anxious group. We also report significant conflict related bias across all blocks, trialwise, using a logistic mixed model, model reveals high approach bias for terrainI low conflict trees (positive intercept: 2.15***) while in terrains 2,3,4 (main effect = -0.49***, -0.28**, -0.36***), reduced approach decisions. Specifically, reduction in approach decisions in terrain III and IV was impacted by trait anxiety [Figure 4, last two regressors, slope: 2.15 ± -0.04*** (III), 2.15 ± -0.05*** (IV), p< 0.001] indicating an avoidance bias due to reversal and increased conflict in individuals with high trait anxiety.

We then asked if stimulus-outcome reversal affects decision making?
By keeping the tree count similar to terrain II, we flipped the reward-punishment contingencies associated with trees (Green ←→ Red) in terrain III, derived from 'reversal learning paradigms. Based on prior research on reversal learning, wherein anxious individuals displayed weaker learning and performance, we hypothesized sub-optimal performance and therefore higher avoidance amongst high trait anxious individuals in terrain III. Trend show significant negative correlation of approach with Trait anxiety [ts(22)= -2.09, p=0.05*, rpearson = -0.41, CI95%[-0.70, -5.06e-03], npairs =24] suggesting increased avoidance post reversal with increasing trait anxiety.

To understand how reversal impacted the decision process in Low and High TA groups in terrain III we employed HDDM. We hypothesized higher decision uncertainty leading to lower drift rate (v) in high TA group and lower bias for approach in terrain III, post reversal. High TA group displayed reduced approach bias (z; see Figure 5, Terrain 3, Bias) for the high and no conflict trees (z; High TA: No conflict: 0.5 ± 0.04; High conflict: 0.6 ± 0.02; Low TA: No conflict: 0.6 ± 0.04, High conflict: 0.6 ± 0.03). For these trees the drift rates (v; see Figure 5, Terrain 3, Drift rate) were also marginally lower (v; High TA: No Conflict: 1.2 ± 0.28; High conflict: 1.0 ± 0.27; Low TA: No conflict: 1.5 ± 0.31, High conflict: 1.2 ± 0.28). These results suggest that while high TA participants learned about the high punishment trees in Terrain 3 they could not unlearn the previous negative association from the earlier blocks.

How does a more aversive environment, with higher punishment encounter rate (higher Pavlovian conflict), impact approach-avoidance decision?
We adjusted terrain I, to increase the punishment frequency compared to reward. That is, the reward to punishment ratio was reduced from 7:3 to 3:7. We hypothesized that high trait anxious individuals would now display an even higher avoidance bias. And this block would really test the limits of their cognitive control capacity to override Pavlovian conflict. As expected, we obtained a very significant negative correlation between approach percentage and trait anxiety [ts(22)= -3.29, p< 0.001***, rpearson = -0.57, CI95%[-0.79, -0.22], npairs =24] showing high avoidance as trait anxiety increases. There's significant avoidance in terrain IV in the high TA group compared to low TA (MeanapIV: LTA = 87.4, HTA = 77.2, p = 0.03*). Aversive nature of the environment strongly biased the avoidance decisions for not only high conflict options but even for no conflict options in the high TA group. Notice the reduced approach percentage in the illustration for the no conflict trees (Figure 3, terrain 4, No conflict trees, Low TA: 87.6 ± 3.9, High TA: 75.7 ± 3.7).
HDDM analysis to understand the mechanisms supported the increased pavlovian conflict in high TA group. This group displayed significantly low drift rate for No conflict option (v; Low TA: 0.5 ± 0.02; High TA: 0.8 ± 0.27) and a reduced approach bias (z; Low TA: 0.6 ± 0.03; High TA: 0.8 ± 0.27), suggesting inability to suppress the Pavlovian conflict to learn the value of the no conflict option (Figure 5 ib, iib).

4 Discussion
Conflict within a goal-directed task can result in diminished performance, as evidenced by slower reaction times and increased inaccuracies. Cognitive control mechanisms are engaged to overcome conflict by enhancing task relevant processing and attention, thus reducing conflict and improving performance. In this task, the approach motivation is governed by drive for maximum reward while avoidance is driven by losses and sensitivity to shock. This sets off a choice conflict and more accurately an instrumental-pavlovian conflict. Although the task does not parameterize accuracy, reaction time choice data was utilized to understand conflict and decision dynamics through drift diffusion model. Analysis of the drift rate and bias derived from drift diffusion modeling unveiled a heightened level of conflict experienced by individuals with high trait anxiety, particularly evident in situations involving high-conflict choices, as compared to those in the low trait anxiety group. The introduction of alterations in the task environment, coupled with adjustments to the punishment regime, provided additional evidence suggesting a diminished capacity for cognitive control in individuals with high trait anxiety. Nevertheless, for a more nuanced understanding of the mechanisms underlying cognitive control, the incorporation of neural data, such as electroencephalography (EEG), is planned for future experiments. These results thus suggest that Trait anxiety is a heterogeneous construct characterized by sensitivity to conflict, impoverished unlearning of previously established negative associations, and compromised cognitive control.

Further studies are underway to understand mechanisms underlying the deficits in the learning process.

## Developmental stability and segregation of Theory of Mind and Pain networks carry distinct temporal signatures during naturalistic viewing

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INTRODUCTION:
Recent studies [1,3] focus on the early development of Theory-of-Mind in children trying to understand the development of ToM ability beyond the preschool age group and its association with middle childhood and early adolescence and individual differences. Nonetheless, quantitative characterization of the temporal stability measure that captures the variability (i.e., less temporal stability means more variability and vice-versa) over time of these functionally specialized brain regions across neurodevelopment remains completely unexplored. A) We used dFC to quantify temporal stability of functional brain networks in 3-12 years children. Subsequently, we estimated dominant dFC subspaces of ToM and Pain networks to quantify their segregation and differences at early age. B) To further capture ToM network temporal stability, we quantified differences between the dominant dFC subspaces using (i) Angular Distance and (ii) Mahalanobis Distance. Our results indicate that ToM network is segregated from other networks as early as 3-yrs but achieving considerable temporal stability by the age of 5 yrs. C) Finally, we have tested whether the temporal stability of functional networks could predict whether a participant could pass, fail, or give an inconsistent response in ToM related false-belief reasoning task. Finally, we have empirically measured ISCs within ToM and Pain networks of participants.

METHODS AND MATERIALS:
In the current study, we analyzed the early childhood dataset [1], which contained 122 childhood samples (ranging from 3-12 years) and 33 adult samples (Total = 155) [1]. All the participants were healthy and from the local community and had submitted written consent from parent/guardian. The data were collected with approval from the Committee on the Use of Humans as Experimental Subjects (COUHES) at the Massachusetts Institute of Technology. Participants watched a sound-less short animated movie called “Partly Cloudy" for a total duration of 5.6 minutes, and the stimuli were validated to activate ToM and pain regions [1]. A) The ToM regions chosen were - bilateral Temporoparietal Junction (LTPJ and RTPJ), Posterior Cingulate Cortex, Ventro- and Dorso-medial Prefrontal Cortex, and Precuneus, whereas the Pain network regions chosen were – bilateral Middle Frontal Gyrus, bilateral Interior Insula, and bilateral Secondary Sensory Cortex [1]. B) We computed the magnitude of evoked responses to the events in the movie that evoked peak responses. We selected five-time courses (>8 sec) (Total no. of Time-points = 168), from each ROI according to literature [1], of maximum activation in ToM (Time-points with maximum activation = 18-27, 80-90, 92-102, 140-149, 150-159) and Pain networks (Time-points with maximum activation =6-15, 35-49, 69-78, 104-115, 159-168) (total of ten time-courses). We performed BOLD phase coherence and leading eigenvector analysis to estimate dFC matrix and subsequently estimated DFC subspaces for ToM and Pain networks. C) Subsequently, we quantified network temporal stability using dominant dFC Subspaces and estimated angular distance and Mahalanobis distance to quantify the distance between the time points [2]. D) In the previous study [1], six-explicit ToM-related questions were administered for the false-belief task to identify the correlation between brain development and behavioral scores in ToM reasoning across a wide age range of children [1]. After the scan, every child participant completed an explicit ToM assessment, which included explicit false-belief tasks, to evaluate the overall ToM reasoning. Based on the outcome of these explicit false-belief task scores, the participants were categorized into three classes: Pass (5-6 correct answers), inconsistent (3-4 correct answers), and fail (0-2 correct answers). To predict the behavioral score of participants for the false-belief task, we implemented ISC [4].

RESULTS:
We included both ToM and pain networks; we found that 3yrs and 4yrs children’s data exhibited frequent temporal switching activity with very low temporal stability. We found a change in the pattern at age 5-yrs; we were getting more stability, which continued for 7-yr, 8-12 yrs, and adults. We also calculated temporal stability for ToM and pain networks separately. The temporal matrices per age group show higher distance values for All ROIs than the corresponding matrices for ToM or Pain ROIs, and this difference persists through age. We found more temporal stability in pain network for 3 yrs and 4 yrs age groups as compared to temporal stability in ToM network for same age- groups. We were getting more temporal stability for ToM network from 5-yrs and onwards. To validate the results and quantify differences between temporal matrices, the distance values were converted into Z-scores, and Kolmogorov-Smirnov tests for equality of distributions followed by Kruskal Wallis tests were conducted.
Next, we tested our hypothesis that the temporal stability patterns of social brain regions of ToM in 3-12 years could predict behavioral scores of the False-belief task. In the current dataset, out of 122 participants (age ranges 3-12 yrs), 15 participants failed the false-belief task & belonged to 3 yrs and 4 yrs age groups, whereas 23 participants were inconsistent

during tasks and belonged to mostly 3 yrs and 4 yrs and few participants from 5 yrs. 84 participants passed the task; approximately all participants passed the task from 5 yrs age group onward.

We performed temporal stability and ISC analysis for false-belief task performers to validate our results. We compared the results of these two measures. For the participants who passed ToM task, their ISC scores were high for ToM network with high temporal stability, ISC scores and temporal stability were moderate for inconsistent group, and ISC scores and temporal stability were low for fail group. Our results suggested that temporal stability of ToM and pain network could predict performance of ToM-related false-belief tasks.

DISCUSSION:

In this study, we considered ToM and pain networks for anchoring the development of social brain networks in 3-12 years to quantify the temporal stability of these networks. ToM functional specialization is developed as early as 3 years old. As sensory-motor areas are highly active in early childhood, pain network carries distinct temporal stability signatures of development till age 4. Our results revealed: a) ToM network segregated as early as 3-yrs but got specialized from 5-yrs. We got higher temporal stability for the pain network at 3 and 4 years. However, there was a significant change in the pattern of temporal stability at the age of 5-yrs, specifically, higher temporal stability for the ToM network, and continued till 7 years, 8-12 years, & adults. b) We found that the temporal stability measure could predict whether a participant would pass, fail, or be inconsistent in false-belief reasoning tasks. c) Finally, we tested our hypothesis that domain-specific regions for ToM might be similar (high ISC) in children who pass and fail explicit false-belief tasks and found that ISC, ISFC, and temporal stability in all these three independent measures were able to predict success or failure in false-belief task crucial to understand the development of social conceptual networks in 3-12 years old.

# Predicting Perceived Interaction in Dancing Dyads: A Machine Learning Approach

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Introduction

Human beings have the remarkable ability to synchronize their movements with musical stimuli. When dancing with a partner, individuals can coordinate their movements in response to both visual cues from their partner and the underlying rhythm, exemplifying a natural instance of intricate rhythmic-social entertainment. Interpersonal coordination is a well-studied topic in social psychology and has recently gained attention in the context of naturalistic movements in dyadic dancing [2, 5, 4]. Two perceptual variables are utilized to study interpersonal coordination, that is, similarity & interaction. The extent to which dancers horizontally orient towards each other was found to be an important correlate of perceived interaction [2, 5]. In the dyads that were maximally oriented towards each other, postural features like volumetric matching and gestural features like imitation and synchrony were identified to be associated with perceived interaction[2]. The current body of literature has identified features that exhibit only moderate correlations with perceived interaction, but no work exists that attempts to predict perceived interaction using machine learning. Studies have shown the importance of hand gestures in spoken communication [6]. [2] found that dancing dyads who move their hands faster tend to be perceived as more interactive and vice versa. Our study also explores the importance of synchronization between various joints of the two dancers in predicting interaction. We propose the following hypotheses:

- H1: The energy of dyads is positively correlated with interaction.
- H2: Dancers dancing with similar energy in a dyad are perceived as more interactive. In other words, the absolute value of the energy difference between two dancers correlates negatively with interaction.
- H3: Synchronization between the joints in the upper body is more important for predicting interaction than the lower body.

These hypotheses were postulated from our examination of the animations.

Methods

We used a dataset of 128 motion capture recordings from [4] involving eight dyads dancing freely to 16 distinct musical stimuli. Each recording included 3D motion capture data from 20 markers (Figure 1). Mean interaction ratings were collected for each recording through a separate perceptual task.

We extracted Volumetric Matching, Torso Orientation, Imitation, and Synchrony features as outlined in the literature [5, 4]. In addition, we introduced two novel features, Energy and Covariance, which are derived from marker velocity. The velocity of each marker is computed using the Mocap toolbox from the position data. The dancer's energy is defined as the mean square velocity across markers and time frames. Consequently, the dyad's energy is the sum of the two dancers' energies. The covariance of velocity between markers of two dancers xi and xj across X, Y, and Z dimensions is measured using correntropy—a non-linear covariance measure spanning the stimulus period. The correntropy measure has found application in the literature for predicting individuals, genres [3], genders, and personality traits [1] based on music-induced

(1)

Here, σ=12(constant) and T is the number of frames. With 60 time series for each dancer, the process yielded a 60x60 covariance matrix, resulting in a 3600-length feature vector.

We employed machine learning to predict interaction. Initial steps included categorizing interaction based on quantiles: 'low' (< 1/3 quantile), 'medium' (1/3 to 2/3 quantile), and 'high'
(> 2/3 quantile). For dimensionality reduction, Principal Component Analysis was applied, and Linear Support Vector Machine algorithm was employed for classification. We used nested cross-validation with stratified sampling to ensure generalizability, tuning hyperparameters like component retention and 'C' for SVM.

The machine learning model was trained on the covariance feature alone to identify significant joint pairs between dancers for predicting interaction. The entire pipeline is illustrated in (Figure 2). Using weights from the linear SVM, we identified the highest-weighted principal component and used its loadings' absolute values to measure marker pair importance. Using the series of transformations in Figure 3, the original 60x60 weight matrix is converted into a
10x10 symmetric matrix representing joint pair importance. Additionally, we evaluated the efficacy of features from literature along with our novel feature, Energy for predicting interaction. We trained the classifier separately on these features and then combined the features with the covariance matrix. We also explored two-class classifications using low and high categories.

Results

We found support for both hypotheses with a correlation of r=0.38(p<0.001) for the first and r=0.33(p<0.001) for the second hypothesis. 4-fold mean cross-validation classification accuracies are reported in Table 1. The joint pair importance matrix is shown in Figure 4.

Discussion

As hypothesized, dyads with higher energy levels and similar dancer energies are perceived as more interactive. Accuracies exceeding chance were attained in both two-class and three-class classifications using all three feature sets. Furthermore, 72% accuracy using the covariance matrix on a two-class classification problem suggests we can rely on the model's learned joint pair importance weights to identify crucial joint pairs. As depicted in Figure 4, we can partition the matrix into three distinct quadrants corresponding to joint pairs in the lower body, between the upper and lower body, and the upper body. The figure demonstrates the importance of the upper body, confirming our third hypothesis. Consistent with earlier research involving dyads and other modalities such as spoken communication, the significance of arms becomes evident, as indicated by the prominent dark band. In conclusion, in addition to supporting our initial hypotheses, this study sheds light on the intricate dynamics of dyadic interaction and the pivotal role of the upper body, particularly the arms.

# Is Mindfulness Related to Socially Conservative Behaviors? Exploring Mindfulness's Relationship with Schwartz's Conservation Values

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Introduction

This study sought to examine the influence of dispositional mindfulness traits on the tendency of adherence to societal norms and the need for stability and security, specifically in the context of the Indian adult population. Although mindfulness research has been picking up pace in recent times, limited research is available on the interplay between trait mindfulness and the human values of conformity (adherence to social norms) and security (need for stability, security, protection) as described in Schwartz's value framework (Schwartz & Cieciuch, 2022). Moreover, in traditional collectivistic societies like India (Chadda & Deb, 2013), individuals aim for harmonious interpersonal relationships by often observing cohesive group practices and customs. Parallelly, mindfulness, defined as the non-judgemental awareness of thoughts, feelings, and sensations in the present moment (Naik et al., 2013), forms a huge part of our ancient knowledge tradition systems. The study thereby explores the dynamic relationship between trait mindfulness and conservation values.

Method

A total sample size of 580 adult participants (291 females, 289 males; mean age=22.517y; sd age= 4.45y) were recruited using purposive and snowball sampling and were administered 3 standardized scales using Google Forms. The revised 'Portrait Values Questionnaire' (Schwartz & Cieciuch, 2022) assessed the personal values with a favorable internal consistency across all value domains for our sample (Cronbach α of security-personal and conformity-interpersonal values being 0.601 and 0.681 respectively). The general psychometric properties of this scale as internal reliability, measurement invariance, and measurement model has been previously cross-culturally validated across 49cultural groups, including India (Schwartz & Cieciuch, 2022).The 'Five Facet Mindfulness Questionnaire' (Baer et al., 2006) was used to measure mindfulness traits with Cronbach α for our sample being 0.814, illustrating a good internal consistency. Although previous studies have confirmed its good construct and conceptual validity in individualistic cultures (Karl et. al., 2020), some studies have reported 'observing' (Mandal et. al., 2016) and 'describing' (Iqbal et. al., 2023) dimensions to be weakly valid in collectivistic cultural context. Hence, we decided to only utilize the total mindfulness score and not the subscale scores. The 'Big Five Inventory' (Goldberg, 1993) was administered for personality with favorable reliability [sample's Cronbach's α ranged from 0.7 to 0.8] and stable internal consistencies across diverse cultural samples has been demonstrated previously (Migliore, 2011). Responses that were error-laden or invalidwere removed by flagging responses which were incomplete, had missing data or had logically inconsistent content (suspiciously patterned/repetitive-responses). Prior to participation, stringent inclusion criteria required all respondents to be currently belonging to an educational institution (bachelors, masters, doctoral, or post-doctoral).

The study sought to understand the contribution of mindfulness beyond personality factors using two-staged hierarchical regression analysis to determine the incremental predictive relationship between trait mindfulness and the personal values of security-personal and conformity-interpersonal.

Results

Bonferroni corrections were performed to control for the potential of Type I errors and family-wise error rate associated with multiple comparisons, giving the adjusted p-value to be 'p=0.00263' for the significance set at 'p=0.05'. On preliminary correlational analysis, a significant negative correlation emerged between conformity-interpersonal values and mindfulness and marginalpositive correlation with security-personal values. Hierarchical regression analyses were conducted to account for the incremental predictive influence of mindfulness on Schwartz's values. The net change in variance of Schwartz's values brought about by mindfulness after accounting for Big Five personality's contribution is denoted by ΔR2. Additional change (Δ) in variance in values explained by mindfulness over personality was computed as follows:

ΔR2 = {Variance Explained by Personality & Mindfulness (Step 2)} - {Variance Explained by Personality (Step 1)}

Even after controlling for personality factors, mindfulness explained ΔR2=2.29% of additional variance for security personal in the positive direction (β=0.125), and ΔR2= 2.85% for conformity interpersonal in a negative direction (β=-0.253). The results imply that mindfulness has an exclusive role in the prediction of Schwartz's conservation values beyond personality factors. Thesemight suggest a complex interplay between the trait of mindfulness and the formation of values of security-personal and conformity-interpersonal within the Indian population.

Discussion

The positive and significant predictive relationship between mindfulness and security-personal beyond the influence of personality factors suggested that individuals who exhibit higher levels of mindfulness are likely to prioritize the security of self and one's immediate environment. The heightened awareness due to a higher level of mindfulness might foster a

sense of psychological security and subjective well-being(McGarrigle & Walsh, 2011)as the individuals pay attention to the immediate present. Increased awareness of one's body and environment help in the regulation of negative emotions such as fear and anxiety (Aldao et. al. 2010), consequently individuals might feel safer and emotionally grounded. Moreover, the negative relationship between mindfulness and conformity-interpersonal after controlling for personality traits suggests that individuals with a higher level of mindfulness are likely to upset or harm other people as they use an internal reference point while making decisions (Karelaia & Reb, 2015) and are less likely to be swayed by external pressure which decreases the tendency to conform. As mindful individuals embrace their authentic selves and free will (Moynihan et. al., 2019), their behavior may result in challenging or deviating from conformity. The findings could have significant implications for understanding the interpersonal and societal aspects by acknowledging the role of mindfulness in shaping attitudes towardssecurity and conformity, since this trait although marginally is predicting only the said personnel values over and above personality traits, the latter being a substantial yet stable contributor to one's behavior. The study also highlights the integration of mindfulness into decision-making based on internal reference points and managing external pressure. Several limitations of the study were also recognized, including the possibility of response bias, validity concerns, sampling bias, and the impact of cultural context.

# A Study of Impact of Interaction Styles on the Social Transmission of False Memory

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Introduction

In the contemporary era dominated by Information and Communication Technology (ICT), social media has become an integral part of daily life, profoundly altering our communication patterns and significantly influencing both personal and professional spheres. Undoubtedly, it has tremendously improved the quality of our lives as far as the speed with which we can connect with people across the continents instantly in an interactive fashion on a real-time basis. However, it is also pertinent to mention that everything in the world has its own demerits and social media is not an exception. Dissemination of false information/ fake news is an undesirable offshoot of ICT and has become a bane of this era.

Thus there is a need for an in-depth exploration of the psychological underpinnings and interaction dynamics involved in the indiscriminate dissemination of false memories within social settings. The focus is particularly relevant in a highly populated country populated country like India, characterized by a collectivistic culture, which exhibits higher susceptibility to the propagation of misinformation. Investigating the intricate mechanisms through which interactions contribute to the formation and transmission of false memories will enable us to understand the complexities of information distortion and enable us to find a method to control the spread of misinformation.

Methods

This study investigate the impact of two interaction styles namely ‘Turn-taking ‘and ‘Free-for-all’, on the transmission of false memory. In the Free-for-all interaction style, communication among the group members is unrestricted and they discuss and recall words together. ; whereas in Turn- taking interaction style, there is a restricted form of communication in which group members take turns to recall the words which they are not allowed to discuss among themselves. These interaction styles are correlated with different social media platforms where some are Free flowing and some are restricted forms of interaction. Collectivistic cultures are strongly oriented towards group harmony and cooperation and this makes people more susceptible to the influence of others. This study hypothesizes that group members who collaborated using a Free-for-all interaction style would produce more false memories than group members who collaborated using a Turn-taking interaction style. This study attempts to determine whether false memories converge in later individual recall for group members who collaborated using different interaction styles. In this study, 30 university students have participated 15 students of each conditions. Each of the three conditions (turn-taking and free for all,) is further divided into ten groups with each group consisting of 3 participants. The sample size of 5 groups have participated in the study. The research design used in this study is quasi-experimental and is divided into three phases for Free for all and Turn-taking conditions.. In Free-for-all and turn-taking condition, there are three phases i.e study phase, delay phase and recall phase. In the study phase, participants will be presented with 150 words from Deese, Roediger and McDermott (DRM) paradigm, after which there will be delay phase where the participants will play a game which is a distractor. The third phase is recall phase where the participants recall based on the given interaction style. The DRM paradigm is one of the most well-known paradigms in the study of false memories and it is widely used on account of its simplicity, ease of use and standardisation of words. The findings of the research shows the effect of interaction styles on the production of false memories and the convergence of it through the modality of visual presentation. This study is novel since the modality of visual presentation is used.

Results

This the study conducted a Welch's One-Way ANOVA to examine the impact of two interaction styles, 'Turn-taking' and 'Free-for-all,' on the transmission of false memory. The analysis focused on four key variables: 'False Memories,' 'Group Recall,' 'Individual False Memory-Average,' and 'Individual Recall-Average. There was no significant difference found between the two conditions. The lack of notable differences in false memory transmission among the studied variables suggests that the 'Turn-taking' and 'Free-for-all' interaction styles did not yield significantly different results concerning the creation of false memories within the examined collectivistic social environment

Discussion

The research, involving 30 university students in a quasi-experimental design, offers valuable insights into false memory dynamics within digital interactions. Results indicated that the "Turn-taking" and "Free-for-all" interaction styles exhibited similar impacts on false memory production. However, the study's limitation in sample size might have affected result significance. For future studies, a larger and diverse samples are recommended, potentially including cross-cultures that would give us insight into the cross cultural differences as well. Moreover, future investigations could explore long-term effects and persistence of false memories, delve into participants' interaction strategies, and conduct content analyses to understand information distortion factors. While this study lays the groundwork, it calls for further exploration into the practical implications of these phenomena in our interconnected world, there is a need for deeper understanding and research while addressing the limitations to expand knowledge in this domain

**Perceived empathy in human and voice-agent interaction**

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Introduction:
Perceived empathy is the ability of humans to form an embodied representation of another human being's emotional state while simultaneously being aware of the causal mechanism that induced that emotional state (Gonzalez-Liencresa et al., 2013). The present study aimed to investigate perceived empathy expressed in a human-voice agent interaction using the "computers as social actors" paradigm in which computers are treated as social agents by the human (Nass et al., 1994). It was hypothesized that empathy shown by voice agents and humans is perceived similarly in a human- voice-agent interaction given the preference for empathetic chatbots (Liu, 2018). It was also hypothesized that context would modulate the level of empathy perceived in a Human-Voice agent empathetic interaction given the finding that social context modulates empathy.

Methods:
Firstly, in the absence of video-based stimuli consisting of a human-voice agent interaction with varied levels of empathy, 16 video stimuli with four conditions (No Empathy shown by both the agents, Both the agents showing Empathy, Only Human actor showing empathy and Only Voice agent showing Empathy) across the four different contexts (Cooking, Plan a Trip, Visit to a doctor and Visit to a Nutritionist) were developed and a rating study was conducted with 31 participants. Participants were required to rate each video on a 10-point Likert scale for likability, valence, level of empathy depicted, and comprehensibility. The video stimuli (Visit to a Nutritionist and Plan a Trip Context) with higher ratings on context comprehension and dialogue understanding across the four empathy conditions were selected for the main experiment. The main experiment examined perceived empathy in a human-voice agent interaction using event related functional MRI (3Tesla fMRI scanner). Participants were required to watch eight videos (1-3 minutes each) inside the scanner that varied across two contexts (Plan a trip and Visit to a nutritionist) and four empathy conditions. After each video, participants had to respond to three statements asking about the level of empathy perceived using the Likert scale inside the scanner.

Results and Discussion
The participants' response to the Likert scale for the three statements (human agent centric, voice agent centric and about the interaction between human and voice agent) was used for analysis and a 2 (context) x 4 (perceived empathy) repeated measures ANOVA was performed. Behavioural results showed a significant effect of perceived empathy (when human/voice /both agents showed empathy ($p < .05$) and context ($p < .05$), when voice/both agents showed empathy. Empathy perceived from a voice agent was modulated by the social context. This is consistent with previous findings (Rosenthal et al., 2014) where participants showed higher levels of empathy across the torture and affection condition in the social context. Empathy conditions created in the video stimuli could modulate the level of empathy perceived from a human-voice agent interaction similarly for both contexts. Previous studies have also shown modulations in the level of perceived empathy for a voice agent. For instance, Carolus et al (2021), showed higher ratings of empathy when human agent treated the voice agent rudely compared to the neutral condition. However, we demonstrate the level of empathy perceived in a human-voice agent interaction by human observers. In addition, previous studies have primarily used social scenarios with negative emotional content likely to trigger higher levels of perceived empathy. In the current study, the content of the script creating day to day social contexts emerged as an important factor in introducing modulations in the levels of perceived empathy.
The fMRI results (FWE Corrected) showed significant activations across empathy conditions in the Superior Temporal Gyrus (STG) which is known to be associated with cognitive empathy and perspective-taking (Frith et al., 2006). The context effect resulted in no statistically significant activation clusters. However, the interaction between context and empathy conditions was supported by activations in the left STG associated with cognitive empathy and perspective-taking (Saxe & Kanwisher 2003). Activations in Insula and posterior cingulate coded for perceived empathy when human agent showed empathy. Interestingly, regions associated with cognitive (inferior frontal gyrus) vs affective empathy (Superior temporal sulcus, insula) coded for perceived empathy for the Plan a trip context vs Visit to a nutritionist context respectively. These findings suggest that social context plays a major role for perceived empathy from a voice agent whereas manipulations of the level of empathy influences perceived empathy from the human agent as well as when both agents are engaged in an empathetic interaction. The content of the script emerged as the most important factor in introducing modulations in the levels of perceived empathy. The social-cognitive regions coding for empathy, intention understanding and semantic processing highlight the role of scripting while training a Voice agent and for the development of social voice agents as digital companions as the developers need to be aware of the observer's psychological processes (Caralous et al., 2021). The current study also highlights the fact that voice agents need not have anthropometric features to elicit social-emotional reactions of the human observers. The study has implications for developers/users/researchers working on voice-based technologies.

**Challenging Workplace Dynamics: Discrimination, Motivation, and Diversity Fatigue in Among Indian Employees**

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Introduction:
While 8 out of 10 organizations report employing women, only a third employ underrepresented groups (e.g., backwards communities, LGBTQIA+ individuals, people with disabilities; Indeed, 2021). Studies have revealed employees face various forms of harassment, including physical, sexual, emotional, and threats, along with exclusion from meetings and sidelining crucial projects. For instance, Indeed (2021) reported that Indian employees couldn't be authentic, express their individuality, were ignored during meetings, and were sexually and physically harassed and abused, which made them feel emotionally and physically threatened. Diversity, equity and inclusion (DEI) initiatives aim to combat discrimination and foster an inclusive workspace. However, not all employees uniformly respond to the proposed changes. The resultant exhaustion and desensitization towards DEI initiatives causes diversity fatigue. A recent survey reported that only 21% of Indian organizations have formal diversity policies, whereas 40% lack formal policies but claim to be inclusive and actively discourage discrimination (ETHRWorld, 2022). However, due to the dearth of literature on diversity fatigue, the authors identified an unexamined gap in studying the influence of work motivation and discrimination levels on diversity fatigue. In the ever-evolving DEI terrain, the priority to employees from underrepresented backgrounds remains constant, making it a crucial juncture to investigate.

Methods:
Our ongoing cross-sectional study aims to examine the associations between discrimination levels and work motivation with diversity fatigue. We employed a convenience purposive sampling method to recruit 110 - 120 participants. The sample includes Indian employees working at organizations with DEI initiatives. We used the Motivation at Work Scale (Gagné et al., 2010) and discrimination subscale from the Chronic Work Discrimination and Harassment scale (Sternthal et al., 2011) to assess work motivation and discrimination, respectively. We adapted the Diversity Fatigue Scale to measure employees' diversity fatigue levels ($\alpha$ = .92; Smith et al., 2021). The questionnaire, created using Qualtrics, was distributed via (1) the researchers' personal contacts and (2) through online social networking platforms and targeted email outreach.

Results: 50 participants (Mage = 26.31, SD = 3.41) responded. With discrimination and diversity fatigue significantly negatively correlated ($p<.001$), we found discrimination levels to significantly and negatively predict diversity fatigue ($p < .001$), indicating that greater discrimination experiences are linked to lower levels of diversity fatigue. Furthermore, a weak association was found between motivation levels and diversity fatigue, suggesting that motivation alone may have a limited influence on diversity fatigue. The overall model demonstrated statistical significance ($p < .001$), i.e., discrimination and motivation explained approximately 25.7% of diversity fatigue. Most participants reported that the identities they felt discriminated against were age (20%), income (12%), gender and physical appearance (9%), and education level (8%). We found employees from a rural background to experience significantly higher discrimination than employees from an urban background. Furthermore, employees aged 35-44 and 45-54 years experienced increased diversity fatigue than employees aged between 18-24 years. This can imply that younger individuals may be more active in combating discrimination and improving diversity, inclusion and equity in their workspace. No other significant differences were found between discrimination, motivation and diversity fatigue with demographics. Work motivation levels did not significantly predict diversity fatigue. No significant associations were found between the subscales of work motivation and diversity fatigue. As more data is gathered, the role of motivation in predicting diversity fatigue may become more evident and significant.

Discussion:
This ongoing study provides significant insight into the complex relationship between diversity fatigue concerning discrimination experiences and employee work motivation levels. Our results show that discrimination negatively predicts diversity fatigue. This suggests that individuals subjected to higher levels of discrimination are more likely to experience lower levels of diversity fatigue. These findings align with DEI initiatives' overarching goal, which seeks to combat discrimination and create inclusive workspaces. However, our study reveals a weak association between work motivation levels and diversity fatigue, implying that while work motivation exerts some influence on diversity fatigue, its effect appears limited. This suggests that motivation alone may not be a primary driver in mitigating diversity fatigue, and additional factors likely contribute to this complex phenomenon. In addition, employees from rural backgrounds experience higher levels of discrimination than their urban counterparts emphasizing the need for targeted interventions in marginalized and underrepresented communities to address their unique struggles. Younger age has also shown to be a significant factor in determining the employees' motivation to combat discrimination and actively engage in efforts to enhance DEI within their workspace compared to older employees. Hence, this study underscores the need for a

multifaceted approach to DEI initiatives that addresses discrimination and considers additional factors contributing to diversity fatigue. By recognizing the potential impact on underrepresented minority groups and demonstrating efforts for diverse participant recruitment, we recommend that future research adopt a mixed-method approach that includes interviews. This approach could provide deeper insights into the motivations behind employee engagement with DEI initiatives. Ultimately, this comprehensive approach aims to shed light on the intricate dynamics of diversity fatigue, benefiting both theoretical knowledge and practical strategies.

**Impact of Social Dynamics on Group Foraging**

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Introduction

Cooperation, a fundamental aspect of human and animal behavior, empowers individuals to achieve goals that would be challenging to attain alone. A striking example of this cooperation can be observed when individuals team up for hunting, enabling the capture of larger, elusive prey—an accomplishment often beyond the reach of solitary efforts. Such collaborative successes have been integral to the evolution of conformity and the acquisition of group norms, as demonstrated by Asch (1951). Yet, the question that emerges is whether individuals conform solely for the sake of acquiring valuable information, termed informational conformity, or do they go further, motivated by the desire to seamlessly blend into the group, which is known as normative compliance? Moreover, we must explore when individuals exhibit these forms of conformity. A compelling possibility is that the degree of conformity hinges on various factors, including the nature of the activity, an individual's expertise in the given task, and the underlying reward structure, as explored by Greenberg and colleagues in 2021. For instance, in evolutionarily significant activities such as foraging, where individuals have been observed to display nearly optimal behaviors, one might argue in favor of informational conformity. In the context of foraging, individuals often know what is best for them and may, therefore, not demonstrate normative conformity. However, whether this hypothesis holds true remains uncertain, forming the basis of our study.

Traditionally, patch foraging has been extensively studied in the wild, and more recently, it has been adapted for laboratory conditions. As previously mentioned, in patchy environments, both animals and humans tend to exhibit behaviors closely aligned with the predictions of the Marginal Value Theorem (MVT), first outlined by Charnov in 1976. These predictions continue to hold true even in controlled lab settings. However, most investigations have concentrated on individual foraging behavior, neglecting the potential impact of group foraging on the optimization of behavior. Can individuals who are suboptimal foragers influence their peers, leading to suboptimal group outcomes? In this study, we explore the dynamics of group foraging through a novel social foraging task, examining whether the collective behavior of the group can steer individual foraging behavior away from optimality—a manifestation of normative conformity.

Lastly, our research also delves into the development of process-level models of learning and decision-making. These models will enable us to gain a deeper understanding of the intricate mechanisms underpinning conformity in these unique conditions.

Methods

In this study, we recruited 64 young adults (32 for each experiment) from IIT Kanpur. The paradigm was adapted for group foraging from solo patch foraging experiments, where individuals collect rewards from resource-rich "patches" (Yonce et al. 2021). Participants were informed in advance that they would be part of a multi-player experiment, although they only interacted with virtual agents. Prior to the experiment, participants received comprehensive instructions through a tutorial video and slides in English, for consistency across subjects.

The main task involved participants being assigned to one of the identical-looking diamond patches. Clicking on it five times amounted to harvesting diamonds. Fewer diamonds were obtained for each subsequent harvest based on a reduction rate. At any point in time they could leave the diamond patch to go to the next one. Clicking the trigger button ten times allowed them to move to a new unharvested diamond patch. Importantly, participants had a limited energy budget: total number of clicks were limited to 750 and the final compensation was based on the diamonds harvested. These constraints required them to balance harvest decisions with decisions to leave to an unharvested patch. Additionally, we synchronised the harvest rate of agents with that of the participants (by making agent click rates equal to the participants' click rate) to ensure similarity in optimality calculations.

Experiment 1: It involved a solo foraging block and a group foraging block. The blocks were counterbalanced across subjects. Virtual agents in the group round either over-harvested or under-harvested. The decision to leave, for both subjects and agents, was reflected by a colour change from red to green. When all the agents and the participant left the patch – when all the dots turned green – the trolley moved to the next patch. However, note that there are no penalties based on time. That is, there are no incentives or punishments for leaving earlier or later.

Experiment 2: In addition to the solo and the group foraging block, we added two more group foraging blocks, referred to as competitive block and a shared rewards block, that were incentivized differently to investigate the effects of varying reward structures and social interactions. Solo and group rounds served as baseline conditions, and the shared and competitive blocks were counterbalanced in order. In the shared rewards block, the total reward accumulated in each patch by the agents and the player was distributed equally among all of them. In the competitive block, we ranked the participant and the agents based on the individual rewards accumulated. Then we split the rewards asymmetrically with the leader getting 80% of the spoils and then the others received 60, 40, 20 % of the reward.

Results

In this section, we will begin by highlighting the key outcomes of our research before delving into the specifics.

Solo Foraging and Near-Optimal Behavior: In the solo foraging condition, participants exhibited near-optimal foraging behavior, aligning with the Marginal Value Theorem (MVT), as expected. This outcome establishes the baseline for individual performance in the foraging task.

Normative Conformity in Group Foraging: When participants engaged in group foraging, deviations from optimality became evident, highlighting the influence of normative conformity. Participants' foraging decisions were notably influenced by the behavior of virtual agents, demonstrating the power of social dynamics.

Influence of Reward Structure on Conformity: The introduction of varying reward structures had a significant impact on conformity. Competitive environments promoted more optimal actions, while shared rewards led to suboptimal behavior and even instances of social loafing, underscoring the role of incentives in shaping foraging decisions.

Hierarchical Drift Diffusion Models (HDDM) Insights: Our application of HDDM sheds light on the underlying decision-making processes. It revealed that motivation, as indicated by drift rate, varied across different conditions, with competitive environments showing the highest motivation levels.

Are individuals optimal in the foraging game?

To test if individuals can forage optimally in this version of the task we assessed their performance in the solo foraging block. As hypothesised, participants tended to be near optimal as prescribed by the Marginal Value Theorem. Fig 1. a showcases the deviations with respect to zero for all subjects in the solo block, which was not significantly different from 0 ($M = 0.83$, $t(31) = 1.90$, $p > 0.05$). MVT stands; subjects were able to arrive at a near-optimal number of harvests per patch!

Do other foragers nudge one's behavior from optimality?

After establishing that they can indeed be near-optimal, we sprinkled in some social dynamics. In the group block, we observed deviations from the optimal harvests (average = 3.78; $t(31) = 5.17$, $p < 0.05$, paired t-test); see Fig 1. b.

However, as we observed in the second experiment participants harvests aligned with near-optimal, Fig 2. a. Deviation from MVT in the group condition was much less than even the solo condition (mean group = 0.30, mean solo = -0.93; Wilcoxon's $W = 95.0$, $p < 0.05$, Cohen's $d = -0.57$). Both experiments highlight strong normative conformity (Fig 1. b and Fig 2. a) despite individual competence in the solo block. Experiment 2's block overview is in Fig 2. b (solo and group plots).

Influencing Conformity through Reward Structure Modulation

Social dynamics and conformity may be influenced by reward structures and environmental factors. As expected, introducing competition by making the payoff asymmetric, reduced conformity (mean: 0.30, SE: ±0.44) compared to the group block (mean: -0.93, SE: ±0.30) (Fig 2. b), making individuals more optimal. Awareness of the confederate's performance in the competitive block resulted in greater exploration by individuals to maximise rewards (exploration stats). In the shared rewards block, however, reduced incentives to perform well led to suboptimal behaviour; deviation from optimal increased ($M = 8.07$, $SE = 1.95$; Cohen's $d = 1.13$). Notably, when the shared block followed the competitive block, some individuals even delayed harvesting until absolutely necessary, indicating some kind of social loafing.

We used a drift-diffusion model (HDDM package) to understand the decision making process in these blocks:

A higher drift rate (V) is indicative of higher value difference (current patch - background) and / or more motivation. Here we can see that the drift rate was highest in the competitive block, followed by group, then solo block, indicating increased motivation as a result of the increase in reward value. Greater boundary separation signifies cautious decision-making (Fig 3. a). The reward structure's impact on separation was examined (Fig 3. b). Competitive block had the lowest, Solo had the highest, showing more caution in Solo decisions compared to Group and Competitive.

Next, we examined the impact of virtual agents leaving the patch on evidence accumulation (motivation). As agents departed, the motivation level of the participant reduced as expected. And this was even more pronounced in the Competitive settings (Fig 3d) vs the Group block (Fig 3c). This effect was quite prominent for the first departure. The steep decrease in value of the current patch when an agent leaves underscores the role of reward structure in social foraging and competitiveness.

Discussion

This study delved into conformity, decision-making, and social dynamics in foraging. While solo foraging displayed near-optimal behaviour, group dynamics led to deviations from optimality, emphasising the influence of normative conformity. Manipulating rewards highlighted the pivotal role of motivation in shaping conformity, with competitive environments promoting more optimal actions. Hierarchical Drift Diffusion Models underscored the changes in motivation driven by conformity in these conditions. These findings emphasise how social influence and incentives impact foraging decisions, shedding light on the interplay of individual and collective behaviours. This research contributes to our understanding of social learning and decision-making, paving the way for future investigations into perception changes upon varying peer and environment structures.

## Uncovering the Process: How one forms Prejudice against another Caste?

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Introduction

Prejudice and discrimination based on caste are still present. According to the 2021 report of NCRB, there are 33593 cases in which the victim was a member of SC/ST.2 A survey shows that students from reserved categories faced ridicule and were blamed by faculty for supposedly lowering IIT academic standards.3 Furthermore, The Delhi High Court permitted changing one's surname to avoid association with a particular caste to prevent potential prejudice against the individual.5 Thus, caste-based prejudice is an implicit reality. Psychological studies on caste are very few. That's why Gorur & Forscher wrote 'Caste Deserves a Seat at the Psychology Research Table.'4 Figure 1 indicates the same. Initial studies dealt with people's attitudes towards the caste system in India (Kuppuswamy,1956). Another argues that socialization and child-rearing practices are responsible for different personality patterns of different castes instead of any inherent differences (Anant,1967). No study attempted to explore the factors that cause caste-based prejudice.

Present work uses Social Dominance Orientation(the extent to which one sees the superiority and dominance of his social group as legitimate), Collective Self-Esteem (to what extent the individuals rate their social group positively), and Intergroup Contact to predict prejudice.

We also explored the role of Realistic (threats to their resources, well-being, power, and jobs) and Symbolic Threat (threats to customs, standards, morals, and religion) as mediators. Esses et al. (2001) found that SDO's link to negative intergroup attitudes was explained by perceived outgroup competitiveness and zero-sum resource beliefs. Frølund Thomsen (2012) demonstrated that contact reduces symbolic threat and weakens over-categorization, promoting ethnic tolerance. Stephan et al. (2016) suggested that individuals with high collective self-esteem are more likely to perceive threats due to their strong commitment to their group's well-being. These studies underpin our current research. Our work aims at answering to these:

RQ1: Do realistic and symbolic threats fully/partially mediate the relationship between Collective Self-Esteem and Caste-based Prejudice?

RQ2: Do realistic and symbolic threats fully/partially mediate the relationship between Social Dominance Orientation and Caste-based Prejudice?

RQ3: Does symbolic threat fully/partially mediates the relationship between Intergroup Contact and Caste-based Prejudice?

Method

The preliminary study was conducted on 61 participants of the unreserved caste (Mean Age=21.40, SD=1.38). The adopted version of Collective Self-Esteem7, Social Dominance Orientation-7, Intergroup Contact8, and the adapted version of Realistic, Symbolic Threat, and Prejudice9 questionnaire were used. All predictors and mediators were measured on a 7-point scale, while Prejudice was measured on a 5-point scale.

Results

Table 1 presents a part of the result. The desire for ingroup dominance is negatively correlated with intergroup contact, meaning that stronger support for social inequality leads to less interaction with disadvantaged group members. Additionally, higher collective self-esteem and social dominance orientation is positively correlated with realistic and symbolic threats, indicating that individuals with a positive view of their social group and those seeking group dominance are more likely to perceive threats to both tangible and intangible resources from the outgroup. In addition, the correlation between intergroup contact and symbolic threat is negative, i.e., greater interaction between groups causes less threat from them on their religion, worldviews, morals, customs, etc.

Table 2 presents unstandardized coefficients (with standard error in the parentheses) of each predictor. In mediation analysis, Symbolic threat fully explains the link between Intergroup Contact and Caste-based Prejudice. In real life, increased interaction with reserved caste members leads to a better understanding of their morals, beliefs, attitudes, and customs, reducing their perception as a threat and, in turn, reducing Caste-based Prejudice. Realistic and Symbolic Threats mediate the relationship between Social Dominance Orientation and Caste-based Prejudice. This suggests that stronger support for social inequalities increases the perception of tangible and intangible asset threats from the outgroup. As the outgroup is seen as threatening, it fosters prejudice among the ingroup.

Discussion

We would be in a better position to discuss the findings once this study is conducted on a larger and more diverse sample. Till now, the results in the preliminary study is congruent with latter works.

# Use of Electronic Visual Display Systems(s) (EVDS) before bedtime and its relationship to Sleep Quality (SQ) and Academic Resilience (AR)

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Introduction

Sleep, as we know, is essential to human health, well-being, and daily functioning, which can impact an individual's mental and physical health (Chanchlani, 2017). Sleep quality (SQ) can be defined as an individual's self-satisfaction with various aspects of their sleep experience, such as their sleep efficiency, sleep latency, sleep duration, and wakefulness after sleep onset. An aggravating factor in the reduced SQ of individuals is the intense use of technology, which is quite frequently displayed by university students. The use of technologies, smartphones and laptops, in particular, has been related to poorer SQ (Dowdell & Clayton. 2019).

Wang, Haertel & Walberg (1994) considered academic resilience (AR) to be a heightened likelihood of success in academic institutions despite environmental adversities that are brought about by stressors. Sleep is also very important in the encoding process as it is negatively influenced by sleep deprivation (Van Der Werf et al., 2009; Yoo et al., 2007; Van Der Werf et al., 2011). Studies strongly suggest that the timing of sleep, as well as its quality and quantity, are linked with students' learning abilities and academic achievement and that students are often chronically sleep-deprived (Curcio et al., 2006; Wolfson and Carskadon, 2003).

An important aggravating factor resulting in reduced SQ has to do with the use of EVDS before bedtime. It is also essential to assess if there exists a relationship between the use of EVDS before bedtime and how it affects both SQ and AR. This can help develop intervention strategies for students to cope better with their academic pressure and develop more AR in them. The current study aimed to find if using EVDS before bedtime impacts SQ and AR among university students.

Method

A convenience sampling method was used to collect the data with a sample size of 1,303 (university students aged between 18 and 26. The samples were collected using the online platform - Google Forms. Questions related to EVDS were included as a part of the demographics, Academic Resilience Scale- 30 (ARS-30) was used to assess their AR, and the Pittsburgh Sleep Quality Index (PSQI) was used to assess their SQ. The online questionnaire was circulated, and the participants completed the survey by giving their consent. The dataset is currently under analysis. The data was analyzed using JAMOVI. Spearman's correlation was used to analyze the relationship between PSQI and ARS-30. The chi-square test of association was used to analyze the difference between the variables used. The Ethics Committee of the University approved the research project. The study was carried out in accordance with the latest version of the Declaration of Helsinki.

Results

A weak negative correlation was found between ARS-30 and PSQI $r(1301) = -0.133$, $p<0.01$. There were no significant gender differences found in the AR and SQ between males, females, and those who preferred not to say.

A chi-square test of association was conducted for various variables. Between adjustment of EVDS light and gender, it was observed that females (92.1%) had the highest rate of adjusting their EVDS light prior to sleep. A statistically significant association was observed ($\chi2 = 9.22$, $p <0.05$), which was weakly associated with Cramér's V= 0.08.

Between gender and ARS-30, it was found that those who preferred not to say their gender had good academic resilience were higher (72.7%), followed by males (49.6%) and females (44.7%). A statistically significant association was observed ($\chi2 = 8.55$, $p <0.05$) , which had a weak association, Cramér's V= 0.08. A statistically significant association was observed between PSQI and duration of EVDS ($\chi2 = 49.3$, $p<0.001$), showing a moderately strong association, Cramér's V= 0.112. Those individuals who used EVDS prior to bedtime for more than 4 hours had severe dysfunction in their sleep quality (50%), followed by those who used it for 2-4 hours (had moderate dysfunction- 33.9%). A statistically significant association was observed between PSQI and a subjective rating of interference of EVDS with sleep ($\chi2 = 66.4$, $p<0.001$), showing a strong association, Cramér's V= 0.226. Those individuals who subjectively rated 'yes' that using EVDS prior to bedtime interfered with their sleep were found to lie between mild-severe dysfunction of sleep. A statistically significant association was observed between PSQI and ARS-30 ($\chi2 = 16.7$, $p<0.001$), showing a moderately strong association, Cramér's V= 0.113. The majority of individuals who do not have sleep dysfunction have good academic resilience (57.5%). The majority of them with mild-severe sleep dysfunction seemed to have moderate academic resilience (as compared to good academic resilience).

Discussion

It was found that AR and SQ had a weak negative correlation, where participants with worse SQ (high PSQI score) also had worse AR (low ARS-30 score). Females showed worse SQ as compared to males. Those who used EVDS for longer,

kept their devices under the pillow, and rated their subjective SQ as bad had worse SQ as compared to other categories.

Certain drawbacks of the study include 1) the data that was collected may have been from a particular state alone in India; hence the study was not able to capture the diversity throughout India, 2) there is a possibility of extraneous or multiple confounding variables (which have not been assessed in the study), 3) the results may be generalizable only to the student community - the university population and not to any other settings or contexts, 5) the study relied entirely relied upon self-report data, which can be subjected to social desirability bias, memory recall bias, or other inaccuracies. Certain other factors, such as researcher bias, sampling bias, and resource limitations, may serve as significant limiting factors in the study.

**Variations in QEEG and Cognitive Performance in Students Learning Problems: Assessing the Efficacy of School-Based Cognitive Behavioral Intervention**

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Introduction:

Electroencephalography (EEG) parameters have been an important mechanism for assessing the neuro-cognitive and behavioral correlates of learning difficulty in children for decades. Students with learning difficulty have their academic grades lie below the anticipated scores for students of the same age, class, and school environment. Associated factors such as substance abuse by parent/s, adverse socio-cultural environment, a deficit in learning cognitive skills, sensory deprivation, and demotivation due to deprivation in socio-linguistic interaction are contributing factors. Such conditions strongly negatively influence cognitive and academic performance in school children (Fonseca, 2008). Existing literature explains the role of socioeconomic and cultural conditions in negatively influencing cognitive and academic performance, leading to increased rates of poor school performance and school failure (Fletcher, 2009).

Several neuropsychological studies revealed that learning has idiosyncrasies in childhood, especially regarding neuroplasticity and neurologic maturation (synaptogenesis and myelination). Maturity increases the perceptual, motor, and executive functional capacities with increasingly complex tasks (Fonseca, 2008). QEEG studies report some of the common patterns among children with a learning disability compared to typical children, like- a higher absolute theta power and relative power values with an excess of slow activity, alpha activity deficit, and increased delta activity is reported when severe disability is observed. Studies also suggested an increase in delta and theta powers with a concomitant decrease in alpha power seemed to be related to an immature EEG pattern (Harmony et al., 1990). Studies on EEG characterizations in dyslexic children with learning problems reported that they have more theta power than the alpha power band in the parito-occipital region. The children with a learning disability had more delta and theta absolute powers in fronto-central derivations than the control group. Studies also revealed that the absolute and relative power in delta and theta bands decreases with age while alpha power increases. Beta power values in the right frontal and temporal derivations were lower in children with learning problems, whereas the delta, theta, and alpha EEG components in the left frontal derivations were higher than in the control group of children, suggesting deficits of the functional maturation of the brain structures leading to the deficit of involuntary and voluntary attention, memory and perceptual and analytical–synthetic brain activity compared to the normal age characteristics (Kiroi et al., 2002; Arns et al., 2007).

Research evidence indicates that early intervention can help manage EEG characterizations during resting and activity conditions. Neurofeedback training (NFT) is helpful in the improvement of cognitive deficits, facilitating the connectivity between frontal and posterior parts of the brain and linking between sensory and motor areas, suggesting improvements in attention and working memory of children with learning problems (Mosanezhad-Jeddi & Nazari, 2013). The successful use of NFT for academic and cognitive improvements by decreasing theta and enhancing beta (Othmer et al., 1992), absolute power of delta, theta, alpha, and beta bands decreased after twenty-half-hour neurofeedback sessions on children with a learning disability (Fernandez et al., 2003) and increase in relative alpha, theta, and delta band power values in the FP1FP2 and T3T4 scalp regions under both eyes-closed and eyes-open conditions (Kaushik & Jena, 2022). Studies suggest that learning difficulties are amenable to specific educational interventions. Effective educational intervention improves basic academic skills such as reading and writing and improves the individual's academic achievement levels.

The main aim of the study was to examine the variations in absolute and relative band power of EEG band powers under various cognitive task conditions- eye-closed, eyes-open, hyperventilation, writing, and reading in children facing problems in learning before and after the introduction of the sessions of Program for Enhancing Academic and Behavioral Learning Skills (PEABLS), a cognitive-behavioral intervention. The study also examined the relationship between relative band powers of EEG waveforms through specific cognitive measurements like IQ, working memory, and BGT for perceptual motor skills and organization.

PEABLS is a school-based cognitive-behavioral intervention designed by the author that focuses on developing self-regulation and resiliency skills (Kaushik & Jena, 2021) was introduced to urban slum-based school children for over two months (15 sessions, twice a week) to learn and practice cognitive behavioral skills and academic concepts.. This study reports the comparison of pre and post-EEG relative band power at scalp locations. The primary research questions were: (i) Does the application of intervention on children with learning difficulty change the band power values of QEEG; (ii) to understand EEG characterizations during varied conditions like eye closed, eye open, hyperventilation, reading, and writing conditions, before and after intervention?

Methods and procedure:

In a quasi-experimental pre-test post-test research design, fifty urban slum-based school-going children from grade 3 to grade 7 (mean grade= 4.78, SD= 1.32), age range 8-12 years (mean age= 10.38, SD= 1.39) and average family income of

₹18,420 monthly, reportedly with learning problems were included in the study. Their mean Body Mass Index was 13.88 (SD= 2.01). They had shown low academic performance for two years before starting the study and behavioral issues at school. The mean pre-intervention academic aggregate score was 37.9%, and the mean post-intervention academic aggregate score was 47.78%, with 48% of students scoring in the 31-40% range and 34% of students scoring in the 51-61% range. Their vulnerability to dropping out of school due to frequent academic failures and behavioral problems highlighted their need for this intervention, especially since evidence indicates the problems in multiple domains further elevate that risk (Kellam et al., 2008; Jones et al., 2015). Inclusion criteria for the study comprised of: (i) age range from 8-12 years (3rd to 7th grade), (ii) obtained IQ score ≥ 50 percentile on Raven's Progressive Matrices (Raven, 1998), (iii) failed in class for two consecutive years, (iv) low classroom participation and co-curricular activity, and (v) behavioral issues. The exclusion criteria comprised (i) obtained IQ score ≤ 50 percentile on Raven's Progressive Matrices, (ii) sensory impairments, (iii) any known case of developmental disorder, and (iv) physical disability (as they may have associated co-morbidities). EEG (absolute and relative band power values) and other cognitive measures were used to assess children before and after PEABLS was introduced. For baseline level of academic performance, aggregate scores of each student received in their final term in the previous grade were noted. Post-intervention academic performance of these students was based on aggregate scores received after mid-term exams of their current grade. EEG recordings were conducted on prefrontal (FP1 FP2), temporal (T3 T4), and occipital (O1 O2) scalp locations.

Cognitive measurements:

(i) The Diagnostic Test of Learning Disability (DTLD) (Swarup, 1993) is a screening tool for measuring students' visual and auditory perception and cognitive functioning.

(ii) Raven's Colored Progressive Matrices (RCPM) (Raven, 1938) is the standardized measurement used to assess students' IQ levels.

(iii) The Digit Span Test, forward and backward, a subtest of Malin's Intelligence Test for Indian Children (Malin, 1971), was conducted to assess students' working memory status.

(iv) The Bender Gestalt Test was administered to assess visual-motor functioning, developmental disorders, and neurological impairments in students (Koppitz, 1964).

Electrophysiological measures:

QEEG of the participants was recorded twice at the gap of 2 months, at the psychophysiology lab of the Department of Applied Psychology, University of Delhi. EEG was acquired during three conditions, i.e., two minutes each during eye closed, eye open, hyperventilation, writing, and reading, using a BIOPAC system MP36 (BIOPAC Systems, Inc.), from the four digital channels of the 10–20 system and analyzed with AcqKnowledge 4.1 software MP150, referenced to the linked earlobes (A1–A2). Fig. 1. Shows the process of EEG data acquisition and analysis.

Results:

The Paired t-test values suggested significant variations in the post-intervention EEG absolute and relative power values. Correlation between qEEG parameters and Cognitive data obtained from IQ scores on RCPM, BGT, and Working Memory Status on Digit Span (Forward and Backward) was also studied using Pearson's correlation analysis. Absolute theta and alpha bands and relative delta, theta, and alpha power values were higher. There were significant increases in relative alpha power values in the prefrontal and temporal regions during task conditions. A significant high positive correlation in the children with learning problems between the relative power of alpha, beta O1O2, the relative power of theta, delta T3T4, and the academic scores, IQ, working memory, DTLD, and BGT values. The tables below depict the comparison of relative values of Pre and post- EEG data and the correlation between EEG parameters and cognitive measures.

Discussion:

The overall post-intervention changes were observed in Absolute values of Beta and Delta that significantly decreased at Pre-frontal, Temporal, and Occipital scalp locations. During the writing condition, Absolute Alpha values increased significantly. The Relative values of Alpha and Theta increased significantly, especially during writing and reading conditions. At the same time, Relative Beta significantly decreased during cognitive tasks, especially writing and reading-related tasks at Pre-frontal, Temporal, and Occipital scalp locations. Higher Theta power activity is indicative of lower cortical working. Lubar et al. (1985) suggested that higher theta and lower alpha activity were observed among children having problems in learning and difficulty in the attention process. Harmony et al. (1990) further reported that high delta and theta values and lower alpha power were related to compromised educational performance, while the high alpha level and lower theta indicate moderate learning difficulty. It was further added that higher theta and lower alpha, and high delta reflect cerebral dysfunction. Another study stated that students with learning problems noticed the excessive slower activity of theta power (Jäncke et al., 2006) and an alpha activity deficit (Chabot et al., 2001) when compared to typical children.

Conclusion:

These quantitative electroencephalogram findings in children with learning problems are related to cognitive measures. The findings could be due to brain immaturity and a lack of learning opportunities.Introduction: Electroencephalography (EEG) parameters have been an important mechanism for assessing the neuro-cognitive and behavioral correlates of learning difficulty in children for decades. Students with learning difficulty have their academic grades lie below the anticipated scores for students of the same age, class, and school environment. Associated factors such as substance

abuse by parent/s, adverse socio-cultural environment, a deficit in learning cognitive skills, sensory deprivation, and demotivation due to deprivation in socio-linguistic interaction are contributing factors. Such conditions strongly negatively influence cognitive and academic performance in school children (Fonseca, 2008). Existing literature explains the role of

# Methods to Classification of Participants in Mathematical Cognition: Evidence In Favour of Dimensionality

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Introduction

Mathematics ability is a major contributor to academic achievement. Individuals with mathematics learning difficulties exhibit a deficit in mathematics ability despite average or above-average reading and intellectual ability. To understand the cognitive underpinnings of mathematics learning difficulties, researchers often use the categorical approach, i.e., categorise individuals into different subgroups based on some cut-off points. DSM-5 recommends using the criteria below 1.5 SD or below the 7th percentile in mathematics achievement to diagnose developmental dyscalculia. However, studies have used a wide range of criteria ranging from performance below the 5th percentile to performance below the 35th percentile (Geary et al., 2000; Landerl et al., 2004).

The categorical approach has been criticised for its inherent assumptions for different cognitive predictors for individuals with mathematics learning difficulties and high math achievers (Mishra & Khan, 2022). To counter the limitations of the categorical approach, the dimensional approach has been theorised, which argues that the same cognitive abilities predict the math ability of individuals over the spectrum. Comparing the findings across studies with the categorical and the dimensional approach, researchers have concluded that the categorical approach has no advantage over the dimensional approach (Peters & Ansari, 2019). But to the best of our knowledge, no research has compared both the categorical and dimensional approaches in a single study with one sample and investigated how both approaches differ in predicting cognitive factors associated with mathematics learning. Therefore, this study set out to investigate the usefulness of the categorical and dimensional approaches in investigating the cognitive predictors of mathematical ability.

Method

Participants: A total of 104 children from 3rd and 4th-grade children participated in the school. Extreme outlier data were removed using the criteria of ± 3 IQRin SPSS, and nine data were removed. The final sample included 95 participants (Male = 53, Female =42). For the categorical approach, children were categorized into the mathematics learning difficulties group (MLD) if they scored below the 16th percentile in the arithmetic operation task, and for the high math achieving group (HMA), they scored at the top 16th percentile in the arithmetic operation task. The inverse efficiency score in the arithmetic operation task was used as a measure of their mathematics ability.

Tasks and Design: The following tasks were used to measure different cognitive abilities:

1. Mathematics fluency test, developed by Ben-Gurion University researchers (Gliksman et al., 2022)
2. Dot number comparison task to measure the approximate number system
3. Colour word Stroop task was used to measure inhibitory skill.
4. Mental rotation task was used to measure spatial ability.
5. Reverse Corsi Block test was used to measure visuospatial working memory.

Procedure: This study has been approved by the Institute Ethics Committee. All the experiments were conducted on a 15.6-inch laptop in a quiet room. Each experiment lasted for 3-4 minutes and was conducted in a randomised order. Participants were given short breaks after each experiment.

Results

Categorical Perspective

Mixed factorial ANOVA was used to analyse the performance in different tasks. The results revealed that both groups did not differ in accuracy in the dot number comparison and Stroop tasks. However, the main effects of congruency were significant. The main effect of response time in the Stroop task was also significant, MLD group had a higher response time than the HMA group. One–way ANOVA results revealed that there was a main effect of group on the Reverse Corsi Block test; the MLD group had a lower visuospatial working memory span than the HMA group. In the mental rotation task, there was a significant main effect of group, and the MLD group had lower accuracy than the HMA group.

Dimensional Perspective: The dimensional perspective was investigated using all the data of participants after removing the outliers. To understand the specific role played by each factor in predicting the mathematics inverse efficiency score, a hierarchical regression model was conducted with the math score as the dependent variable and performance in the dot comparison, Stroop task, visuospatial working memory, and mental rotation along with demographic variables as predictors. The results of regression revealed that only visuospatial working memory emerged as a significant predictor.

Discussion

Thepurpose of this investigation was to explore the cognitive underpinnings of mathematics ability using the categorical and dimensional approaches of mathematical cognition. The categorical approach reported a deficit in spatial ability and visuospatial working memory among children with mathematical difficulty in comparison to high math-achieving children. In

contrast to the categorical approach, the dimensional approach favours an association between math ability and visuospatial working memory.

The study has identified the important role of visuospatial working memory and spatial ability in arithmetic ability. The investigation also points out a weaker association of the approximate number system in arithmetic ability. The study failed to report a significant contribution of inhibitory control in arithmetic ability. The findings of the study establish that the dimensional approach has an enormous advantage over the categorical approach of investigation. It provides more control and higher statistical power to the findings. The new insights gained from the current study should help future research to better identify cognitive predictors of mathematics ability and plan intervention studies for developmental dyscalculia.

**Exploring the interplay of culture, cognition and child development: Insights from case studies of indigenous children of India.**

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India is the world's largest country with indigenous communities, which makes India a diverse nation in cross-cultural research. Researchers in cognitive science have yet to utilise this diversity to its full potential. The establishment of cognitive science was driven by integrating perspectives and research methodologies from its founding disciplines to create a coherent, well-integrated "Science of the mind" (Gardner, 1985). By exploring the rich cultural landscape of India, cognitive science researchers could gain valuable insights into how different cultural contexts shape cognition. This could be possible if anthropology is given due importance in cognitive science research theoretically and methodologically. Anthropology, at one time, was a pioneer in the cognitive revolution (D'Andrade, 1995; Gardner, 1985). However, over time, it has become a "missing discipline" as its presence and impact have steadily diminished (Boden, 2006; Nunez et al., 2019). This review is structured to understand the impact of societal cognition on indigenous children through case studies of indigenous communities in their cultural contexts. Secondly, it aims to understand how integrating the methodology of psychology and anthropology can better understand child development. The results from the case studies suggested that societal cognition (aspects of cognition targeted at large-scale social processes such as morality, religion, cultural values and worldviews) plays a significant role in the early childhood development of indigenous children, which has a major impact on all components of cognition (Individual, Interpersonal and Societal) (Barrett, HC, 2020).

The methodology is a comprehensive literature review to understand the theoretical dimensions of cognition, culture and child development of the indigenous children of India. To provide preliminary data, this study is based on thirty review studies, twenty ethnographic studies and two books. A case study method was employed to study the influence of societal cognition on child development with a thorough analysis of case studies of indigenous tribes, namely Birhor and Oraon of Jharkhand; Santhals, Ho and rural children of Odisha; and Nayakas from Nilgiris, Tamilnadu. Additionally, two types of methodological analysis were used in the study of child development: one from the psychological perspective, where various psychological tests were used, and the other is the anthropological perspective, with observation and interviews as the study method to measure cognitive processes.

The results suggested that cognition has been studied as a unitary concept of individual cognition, and various cognitive theories have been based on that. However, recent research has categorised cognition into three types- individual (subjective mental activity of the world and self like perception, attention, reasoning and executive functions), interpersonal (processes that have direct social interaction with others like the presentation of self and communication) and societal cognition (Aspects of cognition and processes with large-scale social processes like morality, religion and cultural & worldviews). This research gap has suggested a need to study societal cognition as it can influence all levels of cognition (Barrett HC, 2020). Finally, from the above case studies of indigenous children, it was inferred that all these communities placed the highest importance on societal cognition right from early childhood development, like observing, modelling, active participation in social activities, playing and learning by doing, as children are outstanding social learners. Societal cognition reflects that learning is a collaborative process that occurs within the context of one's community. The early acquisition of this cultural knowledge helps them develop cognitive skills to navigate their environment.
Cross-cultural Cognitive Science (CCCS) research emphasises that physical, social and linguistic environments could shape individual cognition through processes like plasticity and reaction norms (Barrett HC, 2020). The above case studies indicated that societal cognition was crucial in developing the cognitive development of indigenous children in a cultural context. The two major limitations of cognitive science research persist in its reliance on convenience sampling, predominantly consisting of students from colleges, and generalisation of research from Western, Educated, Industrialised, Rich, and Democratic (WEIRD) countries to the rest of the world (Machery, E. et al., 2023). From the above case studies, we can infer that if cognitive scientists intend to study cognition (individual, interpersonal and societal) in a broader aspect, they should consider an interdisciplinary perspective for its evaluation. The above case studies showed the importance of culturally embedded societal cognition in child development. A thorough analysis of this societal cognition is needed to claim the universality of cognitive processes and to understand how they may vary across different cultural contexts.
Given that cognitive scientists are not trained in Anthropology-based study, an interdisciplinary approach is required to ensure their research considers cognitive processes and behaviour in a cultural context. Integrating both fields of study can yield valuable theoretical and empirical perspectives essential for understanding intricate phenomena such as cognition, culture and child development. An in-depth understanding of how various cultural factors shape cognitive processes and child development can help to have practical applications in areas such as education and mental health, to name a few. This methodological integration also promotes cultural sensitivity and awareness, leading to more effective cross-cultural studies in naturalistic settings rather than a surface-level knowledge of these cultures that comes mainly from surveys and interviews with outside agents. Future research in this area could provide valuable insights across diverse populations.

## Effect of knowledge on Visualization: An Eye Tracking Study

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Background knowledge has a profound impact on our perceptions and interpretations of the world [1,2]. Our prior experiences, beliefs, and expectations play a critical role in shaping how we process information and make sense of new information [3]. The gaze patterns and eye movements reveal information about visual attention, perception, and decision-making processes, hence, providing valuable insights into how we interpret and process new information [4]. Previous research studying knowledge-expertise have identified total scanning duration, total fixation duration, fixation count, and total saccadic duration as important eye markers. In this study, we investigate eye movement patterns in individuals with different educational backgrounds to assess their past knowledge. The current study attempts to see if eye markers may be indicators of knowledge in a given domain.

The design of this experiment received clearance from the ethical committee of institute (No. IIT/SRIC/DR/2019) to proceed with the experiment. Experiments were conducted on 60 graduate students (Mean age: 27; SD: 2.98) matched on Intelligence [6] and divided into two groups - Architecture (Group 1) and Economics (Group 2). The participants in this study had a normal or corrected-to-normal vision and reported having no history of neurological or psychological problems. Further, to control effects of intelligence on performance of problem-solving tasks, Raven's Advanced Progressive Matrix (RAPM) [6] was administered to select a homogeneous group of 60 participants. Participant were presented with two tasks (a) General problem-solving task (an unbiased task requiring low background knowledge) and (b) a task based on architectural concepts (biased task requiring knowledge of subject domain). Both groups were given all the problems. Counterbalancing technique was used for problem presentation. Participants whose weighted gaze was less than 80% were excluded during screening. Before beginning the data-collecting process, the eyes of each participant were calibrated with the use of an eye-tracking device (Model: Tobii Pro X3-120) that was mounted below an HP 24f display (24 inches, 60 Hz) with a screen resolution of 1920 x 1080 pixels.

The participants were seated 60 cm from the display in a closed-door, noise-free room. Each participant was given two tasks: Based on CLEVR Dataset and Architecture-Biased Set Each task consisted of 4 questions. Performance based responses and total time taken in the tasks were recorded. Tobii X3-120 was used to capture eye parameters during task performance. Simultaneously, audio and video were recorded during the task for further checks. Oculometric data of fixations, saccades and pupil-based parameters were collected while participants performed the task, and the gaze patterns were analysed to identify distinctive markers that are related to background knowledge.

Our pre-processing methodology was divided into four stages [7]. The initial stage was to remove any missing data points, such as eye blinks and out-of-focus gaze locations. The pixel coordinates of two successive gaze samples were then utilised to calculate the Euclidean distance between them. Third, the time between samples was calculated by subtracting the timestamp of the previous sample from the timestamp of the present sample. Finally, the gaze velocities were calculated by dividing the distance travelled by the eyes by the time difference between samples. The data was analysed using custom Python programs. Then the data of statistics obtained from data viewer is processed using IBM SPSS 23 software with Multivariate Analysis of Variance (MANOVA) test.

There was no significant difference between the two groups in the unbiased problem. Significant differences in eye markers were observed between the Group 1 and Group 2 in domain rich problems. Peak saccadic velocity and mean pupil diameter along with time-correlated parameters (total scanning duration, total fixation duration, total saccadic duration, and fixation count) were found to be signature markers in domain-biased question to differentiate people with domain-knowledge and novice. Our study reveals that eye movements during a task maybe a valuable indicator of past knowledge in similar tasks. So far time-based oculometric parameters have been reported as significant markers of expertise, we found saccadic parameters and pupil-based parameters as important markers varying with knowledge.

This study highlights the importance of considering an individual's background knowledge in various fields, as it can greatly impact their perceptions, interpretations, and decision-making. The findings will be helpful in understanding attentional biases and cognitive load in visual processing due to knowledge expertise and/or deficiency The results of this study contribute to a deeper understanding of the influence of prior experience on visual attention and perception. Findings of this study can be used to create individualised tutorial systems and therapeutic programs for individuals with Specific Learning Disorders. It will assist in understanding attentional biases and the visual processing in working memory in these disorders. Further research with a larger populace of diverse academic backgrounds is necessary to validate and generalise the findings.

**Quantifying the Effects: A Mathematical Analysis of Mindfulness Meditation on Visual Working Memory**

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*Computer Science*

The purpose of this study was to evaluate the effects of a one-month mindfulness meditation training program on the ability to complete working memory tasks when faced with demanding visual stimuli. Participants went through training after being split into meditation and control groups. Prior to and following training, we assessed accuracy, RT, and RT variability. EZ Diffusion and Noisy Exemplar analytical models were used to identify the underlying mechanisms.

The EZD model showed that the meditation group displayed enhanced drift rate (better perceptual information) and reduced decision boundary (quicker reactions). In the meditation group, there were less attentional lapses, according to the Noisy Exemplar model of encoding noise. These findings show that mindfulness meditation strengthens working memory by enhancing focus and perception. In order to provide a thorough grasp of mindfulness's cognitive impacts and to highlight its potential, this study combines behavioral tasks and mathematical models.

# Mindfulness Meditation and Somatosensory Attention: Insights from Frequency and TimeFrequency Analysis of EEG dataset

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Introduction

Mindfulness practices aim to enhance present-moment awareness without judgment, with potential benefits for attentional control(Bokk & Forster, 2022). However, contrasting findings exist regarding mindfulness's effects on attention (e.g., Incagli et al., 2020). The P300 event-related potential (ERP) has been identified as an attention-related neurophysiological marker (Cahn & Polich, 2009), and its alterations have been observed in mindfulness practitioners (Delgado-Pastor et al., 2013).

While the effects of mindfulness on the P300 have been explored, understanding its impact on somatosensory attention remains limited. Bokk and Forster (2022) investigated this using EEG and an oddball paradigm and found that mindfulness meditation may preserve somatosensory attention during task repetition as suggested by intact P300 ERP post-meditation as opposed to a control group. However, they did not find a significant difference between the groups in the behavioral measure before and after the interventions (oddball counting task), and performance increased for both the groups post-intervention, reflecting a general task repetition effect (Bokk & Forster, 2022).

Beyond ERP analysis, it is important to explore EEG dynamics, including event-related spectral perturbations (ERSP) and inter-trial coherence (ITC), to study brain responses to stimuli. This study builds on Bokk and Forster (2022) by incorporating frequency and time-frequency analyses, offering a more comprehensive understanding of how mindfulness meditation impacts somatosensory attention.

Methods

The raw dataset comprises EEG data collected from 50 (M = 30, F = 20) participants with an average age of 30.3 years while participants performed a tactile oddball task before and after a guided breathing meditation (Kabat-Zinn, 2017) (meditation group) or listened to a philosophy audio clip (control group) (Bokk & Forster, 2022).

We performed preprocessing steps on the dataset, which involved resampling the data from 500 Hz to 250 Hz, high-pass filtering at 1 Hz, low-pass filtering at 40 Hz, average referencing, and interpolating bad channels. Further preprocessing (artifact removal using ICA decomposition) and statistical analysis were conducted in EEGLAB.

Statistical analyses like t-tests were performed to assess group differences and condition differences for channel measures related to P300 using selected frequency bands and midline channels (Pz, Cpz, Cz, Fcz, and Fz) with statistical significance set at $p < .05$. Bonferroni correction was applied to control for multiple comparisons.

Results

Frequencyanalysis

Between-subjects analyses comparing average power spectra (midline electrodes and whole scalp) and power spectrum at the Pz electrode post-intervention found no significant differences between the meditation and control groups ($p < .05$, see Figure 1). Since between-subjects analysis showed no significant differences, within-subject comparisons between pre-test and post-test conditions were conducted for both groups separately. However, power spectra results did not reveal any significant effects of the interventions for both groups ($p<.05$, see Figures 2 & 3)Time-Frequency Analysis

Between-subjects comparison did not reveal a significant difference in ERSP between groups both pre and post-interventions (see figs 4 and 5). There were no baseline differences in ERSP.

Within-subject event-related spectral perturbations (ERSP) associated with the P300 ERP were analyzed between pre-test and post-test conditions for both groups. The time window of interest was 200 to 500 milliseconds.

In the control group, averaged ERSP for midline electrodes displayed a significant decrease in event-related spectral power ($p < .05$) across major “theta”, “alpha” and “beta” bands, with most prominent effect on beta band (see Figure 6). These changes primarily occurred within 150 to 300 ms, preceding the P300 ERP. The Pz electrode showed a similar trend in all frequency bands (see Figure 7).

Discussion

In the frequency analysis, between-subjects analyses comparing the control and meditation groups revealed no significant differences in the average power spectra post-intervention. Within-subject comparisons between pre-and post-intervention conditions also showed no significant effect on the power spectra in either the meditation or control groups. This suggests that both groups exhibited similar overall brain activity patterns both pre and post-intervention, implying that the short mindfulness meditation intervention did not immediately alter overall brain activity patterns. This is consistent with previous studies reporting mixed results regarding the immediate effects of mindfulness meditation on brain activity, especially in novice participants (Lomas et al., 2015).

Within-subjects time-frequency analysis revealed significant decreases in event-related spectral power for the control group in the theta, alpha and beta bands. Such a decrease was not found in the meditation group. The effect was most prominent and widespread in the beta band, which earlier studies have implicated in somatosensory attention (eg., Bardouille et al ., 2010). The non-significant decreases in event-related spectral power (ERSP) in the meditation group compared to the control group suggest a potential protective effect of mindfulness meditation on attentional resources (Bokk & Forster, 2022) through modulation of event-related power in the theta, alpha, and beta bands, with most prominent modulation in the beta band. This aligns with the idea that mindfulness meditation enhances attentional capacities and prevents resource depletion (eg., Jha et al., 2010). However, these changes were primarily observed in a time range of 150 to 300 ms, suggesting that the observed spectral changes may not be directly linked to the P300 ERP, but may reflect modulations in neural activity related to early attentional processes.

While the findings challenge the hypothesis that mindfulness meditation leads to broad attentional improvements, they underscore the need to explore further the relationship between somatosensory attention and meditation, which remains relatively uncharted territory. The study contributes to understanding the impact of mindfulness meditation on brain activity during attentional processes, highlighting selective modulations in event-related spectral power, particularly in the alpha band. Future research could delve into longer-term interventions and individual differences in response to mindfulness meditation to gain a more comprehensive understanding of its effects on somatosensory attention.

# Evaluation of Cognitive Performance and Neurophysiological Functions After Repeated Immersion in Cold Water

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Introduction

Cold water immersion (CWI) has a long-standing tradition in cultures like India, where it is integrated into daily life through early morning bathing rituals in cold bodies of water, rooted in both religious beliefs and overall well-being. This practice encompasses therapeutic, religious, and recreational aspects, highlighting its deep historical significance. Typically defined as water below 15°C (Knechtle et al., 2020), CWI carries both physiological and psychological implications. Recent attention from researchers and practitioners has illuminated its potential for enhancing athletic performance, mitigating inflammation, and bolstering mental well-being (Jones et al., 2019).

Exposure to cold water activates the amygdala, causing fear due to evolutionary instincts (Angilletta et al., 2019). The body undergoes immediate cold shock with increased heart rate, blood pressure, and gasping reflex. This activates the sympathetic nervous system and releases endorphins, reducing cold sensations and improving mood (Espeland et al., 2022). CWI induces the release of the cold shock protein RBM3, promoting synapse repair and preventing cognitive decline (Peretti et al., 2015). High dopamine levels from cold water exposure enhance motivation, arousal, and executive function, persisting for hours without negative effects (Juárez Olguín et al., 2015; Šrámek et al., 2000). Cold plunges challenge mental resilience, akin to elite training, aiding in handling life's discomforts. Cold stress may positively impact the HPA axis and reduce fatigue (Shevchuk, 2007).

Limited research has delved into the effects of head-out, whole-body CWI in the Indian context, and investigating its cognitive and neurophysiological consequences for diverse populations is crucial. This research may offer insights into optimizing the practice's benefits and illuminating cognitive functions. By exploring these aspects, we can potentially reveal new dimensions of human adaptability and resilience, enhancing our understanding of the cognitive appeal of CWI.

Methods

Design: Pre-Post, Single blinded, Quasi-Experimental study
Variables: Independent variables (IVs)
Condition 1: Acute CWI
Temperature - 10 ° C (extreme cold stress)
Immersion- 10 secs * 3 reps; 30 secs * 3 reps; 1 mi * 3 reps
Rest time- 20 secs between each rep
Condition 2: Acclimatized CWI
Temperature - 15 ° C (cold but gets comfortable in few mins)
Immersion- 20 mins (only 1 rep)
Dependent variables (DVs)
Biochemical - Salivary cortisol, Salivary alpha-amylase, blood glucose.
Psychological- Resilience, Mood.
Cognitive- Sustained attention, Reaction time, Working memory, Decision making
Physical- Blood pressure, Pulse rate, Oxygen levels.
Tools

- Connor-Davidson Resilience Scale (CD-RISC)
- Brief Resilience Scale (BRS)
- Positive and Negative Affect Schedule (PANAS)
- Balloon Analog Risk Task (BART); PEBL
- Psychomotor Vigilance Test (PVT); PEBL
- Color Stroop task; PEBL
- Operation span task; PEBL
- Oximeter
- BP machine
- Glucometer
- Biochemical methods

Participants

- 40 healthy young adults aged 18-40.
- Convenience sampling, randomly assigned to the two groups.
- Eligibility criteria: no chronic pain, no medication use, no medical/psychiatric/substance use disorders, not pregnant (females), no recent cold-water immersion.

Procedure

The experiment took place in Chennai, where 40 healthy young adults aged 18-40 were recruited through word of mouth and social media. They were randomly divided into two groups, with 20 participants in each condition. They underwent pre-intervention training encompassing mindfulness and deep breathing techniques to push their limits and be aware of the present. Ethical consent was obtained, and pre-tests were conducted. To familiarize participants, a trial immersion in 20°C water was administered hence, hypothermia was also tested.

Subsequently, a 7-day intervention (head out, whole-body CWI) was executed, followed by post-tests on the 7th day after an hour of relaxation. The time of day for the intervention was controlled, with the intervention and data collection occurring between 6 a.m. and 8 a.m. for all participants. During the period of immersion, a thermometer was used to control the water temperature meticulously.

Results

The results from the Paired Samples T-Test and Wilcoxon W analysis reveal significant changes in various variables following CWI:

- There was a significant difference between the pre-test and post-test in resilience, as evidenced by a p-value of 0.001 and a mean difference (M) of 10.23 in the Brief Resilience Scale (BRS), as well as a p-value of less than 0.001 and an M of -15.00 in the Connor-Davidson Resilience Scale (CDRS).
- Mood exhibited significant changes, with a p-value of less than 0.001 and an M of -11.50 in Positive mood and a p-value of 0.003 and an M of 6.00 in Negative mood.
- Sustained attention showed significant improvements, with a p-value of less than 0.001 and an M of 4.50 in PPVT (Psychomotor Vigilance Test).
- Risk-taking behavior demonstrated significant changes, with a p-value of 0.03 and an M of 28.00 in the Balloon Analog Risk Task (BART).
- Selective attention exhibited a trend toward significance, with a p-value of 0.097 and an M of 11.21 in the Color Stroop task.
- The pulse rate displayed significant changes, with a p-value of 0.004 and an M of 3.50.
- Blood glucose levels significantly changed, with a p-value of less than 0.001 and an M of 12.50.

In all cases, the null hypothesis of no difference is rejected due to the low p-values, signifying noteworthy alterations in the measured variables following cold water immersion.

While data collection has been completed, the salivary samples to measure cortisol and alpha-amylase are yet to be tested and analyzed. The analysis of blood pressure levels, oxygen levels, and working memory data are pending as well. Further, the difference in these variables between the two conditions (10 ° C and 15 ° C ) will be analyzed and discussed. As a result, the discussion section remains a work in progress at this stage

# Synthesizing optimal visual stimuli with deep generative networks

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Introduction

The brain's visual system is organised into a hierarchy of regions that encode progressively more complex visual features. For instance, neurons in lower areas, like the primary visual cortex (V1), respond best to oriented bars, whereas neurons in higher areas, like the fusiform face area (FFA), are more attuned to face-like stimuli. The precise feature sensitivity of these brain areas has been meticulously worked out through decades of research by presenting various examples of stimuli from different categories to animals or humans, while simultaneously recording neural activity in these regions. Nonetheless, given constraints on experimental time, the repertoire of visual categories that have been explored is limited. Thus, few recent studies have utilized deep learning algorithms to synthesize images that activate a single or small population of neurons from specific parts of the animal brain (V1[1], V4[2], IT[3]). These studies are limited to a particular region of the animal brain. Further, since invasive access to the human brain is rare, a recent study (NeuroGen[4]) generates optimal images for predicted activity in different parts of the human brain. However, the synthesized images for early visual regions seem inconsistent with existing literature.

In this study, we seek to synthesize "super-stimuli" – images with features that activate specific areas of the visual cortex much more strongly than conventional categories of images. We extend a previous framework (XDream[5]) that employs a deep generative network (BigGAN-deep[6]) in conjunction with a heuristic optimization approach (genetic algorithm). We build a robust CNN-based encoder for human functional MRI (fMRI) brain responses based on recent work [7] and incorporate the encoder in a closed-loop optimization framework. Our approach generates meaningfully novel "super-stimuli" both for brain regions individually as well as chimeric "super-stimuli" that are jointly optimal for multiple brain regions (e.g., V1+FFA).

Methods

Encoder - a model for fMRI prediction: Beliy et al. [7] designed an encoder-decoder model to reconstruct seen images using fMRI activity. The encoder comprises an AlexNet feature extractor layer, two convolutional layers, followed by a fully connected layer. This was trained on the image-fMRI pair from the Generic Object Decoding dataset [8]. We modified the encoder with a VGG19 [9] feature extractor and trained on a recent dataset [10], which consists of 1200 images-fMRI voxel activity pairs repeated five times for seven participants. We trained the encoder for each region and each participant separately.

BigGAN-deep generative Network: BigGAN-deep is a class conditional generative network trained on the ImageNet [11] dataset, which consists of 1000 classes. It takes a latent (noise) vector and the class category as input for generating images corresponding to a class. BigGAN-deep can generate high-acuity images corresponding to class information. We have utilized BigGAN-deep-128 to generate visual stimuli for our study.

XDream (EXtending DeepDream with real-time evolution for activation maximization): Introduced in [3], the XDream framework was used to highly activate a single or small population of IT neurons by modifying the visual stimuli with the monkey in a closed loop. The framework comprises a generative model (DeepSIM [12]) coupled with a gradient-free optimization technique. The authors have used a genetic algorithm, which is more robust in noisy conditions [5]. This algorithm starts with an initial set of random vectors (N=20), known as codes. These codes are fed to DeepSIM, a class-independent generative network, to generate the same number of images. These images were shown to the macaque monkey while simultaneously recording from the brain's IT region. Based on the firing rates of the IT neuron, a score was assigned to each image. These scores were passed through a fitness function, which determined the probability of selecting a given image as a parent, and a genetic algorithm produced the new child codes for the subsequent generation of images—this iterative procedure with the monkey-in-the-loop synthesized images that strongly activated the recorded neurons. We updated the generative network to BigGAN-deep-128 to generate high-fidelity category-specific images.

Our Approach - Optimal stimuli synthesizing loop

We incorporated the trained encoder to replace the monkey in the modified XDream framework (Fig. 1). To synthesize images that will robustly activate the predicted fMRI activity for specific brain regions, we started with 20 images. Based on the predicted fMRI activity, parent images were selected, and 2 parent images' latent codes were combined in a 1:1 ratio with a mutation probability of 0.5 and a mutation size drawn from a normal distribution ($\sigma = 0.5$) to generate child images. We observed that the images started converging near the 40th generation and saturated around generation 50. Thus, we continued the iteration till generation 50.

Results

Experiment 1: Images generated from single region optimization

We generated the optimal stimuli for each participant and region using the subject and region-specific encoders. Fig. 3

shows the generated super stimuli for selected early and later regions across multiple participant and class categories. In the case of the early visual regions (e.g., V1), we observed that the images generated have high spatial frequency information, such as oriented bars, which progressively morphed into more complex structures along the visual hierarchy. For FFA, we found features of faces, and PPA shows features associated with places. This is seen across participants and regions.

Experiment 2: Images generated from joint optimization from two regions

Since different brain regions work together to help us perceive different visual objects, we asked what stimuli would maximally activate a combination of different regions. These types of studies require invasive (lesioning or inactivating) access to the animal brain. Here, we performed the same experiment non-invasively on models of different brain regions. In this, we either enhanced the activity of one region of interest (ROI) while suppressing the other region (activity(ROI1) − activity(ROI2)) or we jointly increased the activity for both the regions (activity(ROI1)+ activity(ROI2)). Since the number of voxels differs for each region, we consider the average activity from each region for this analysis.

We show two examples (Fig. 4) of joint optimization from the encoder of Participant 4.

V1+FFA: When FFA is suppressed while enhancing V1, the generated images have finer details. While, when V1 is suppressed and FFA is enhanced, we see no high spatial frequency details. When both regions are enhanced, we see high spatial frequency information with more faces.

PPA+FFA: In the first case (of Panda), when we suppressed FFA and enhanced PPA, we observed place-like structures (possibly cage or forest) getting generated. On the other hand, suppressing PPA while enhancing FFA focuses on the facial features of the panda. While both regions are enhanced, the panda seems to be outdoors.

Discussion

We demonstrated that our method could synthesize meaningful optimal stimuli for the predicted fMRI activity of each region. The synthesized images depend on the seed images and the class category. Further, we see images morphing from one class into another – due to class leakage. This, in turn, is helping the algorithm to find features suitable for a brain region. In ongoing work, we seek to validate the images generated by this approach by directly measuring human visual cortex responses to these images “live” inside the fMRI scanner. This approach can help us understand how different brain regions (visual and possibly non-visual cortex) process visual information, which can have implications for neuroscience research. Furthermore, by understanding how different regions of the brain process visual information, we can develop interfaces that can interpret and respond to visual stimuli in real-time.

# Discovering Serial Dependence with SequenceAware Neural Networks

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Introduction

Serial dependence is the phenomenon where past experiences influence our current behavior, even when these past experiences are objectively irrelevant to the task at hand [1]. We have chosen three experiments performed in our lab, which invoke different cognitive processes (see next section), to quantify serial dependence and understand how cognitive factors influence it. Previously, serial dependence has been studied with models that incorporate strong, and often simplifying, assumptions on the decision-making process ([2], [3]). Here, we use powerful sequence-aware neural networks (SANNs) that enable extracting sensitive metrics of serial dependence directly from behavioral data. SANNs fall into one of various types, such as conventional recurrent neural networks (RNNs), long short-term memory networks (LSTMs) [4] and position-encoded Transformers [5]. Here, we employed LSTMs for serial dependence detection.

Methods

Experiment Details:

Details of the experiments, engaging distinct cognitive phenomena, are as follows:

The Cued Change Detection (CCD) Task explores attention mechanisms using a Posner cueing paradigm [6]. Participants view two oriented gratings in each trial, with one cued for attention ("cued grating"). After a short delay, the gratings flash and after the flash either one or none of the gratings change orientation (Fig. 1a). 20% of the trials are "No Change" trials and remaining trials have 75% cue validity. Participants identify the changed grating and were informed that the cued grating is more likely to change its orientation. Data from three different study conditions were analyzed that include 26-28 participants; the different conditions each comprised control cohorts recruited for different behavioral experiments and are not relevant to the question studied here.

The Distractor Working Memory (DWM) Task explores distractor interference in working memory [7]. On each trial two oriented gratings are presented; after a delay, one is cued to be remembered ("cued orientation"). After another variable delay, a distractor grating with random orientation appears in 80% trials (to be ignored by participants). Finally, participants were probed to reproduce a specific grating's orientation using a mouse ("probed orientation") (Fig. 1b). This study includes 26 participants.

The Spatial Reward Modulation (SRM) Task investigates reward-driven attention modulation. In each trial, participants view two oriented gratings and following a flash either, both or none of the gratings could change in orientation [8]. Participants must indicate if a grating's orientation at the response probed location changed. Correct responses earn rewards, displayed as feedback on the screen (Fig. 2). Rewards are constant on "fixed side," while variable on the other side; the specific details regarding reward variability are not relevant for this abstract. Variable side reward can be higher or lower than fixed side reward. Accuracy and reaction time are measured. This study includes 24 participants.

To ensure reliable data and statistical robustness, every participant completed between 250-600 trials. Task variables in sequential trials in each experiment were independently and pseudo randomly sampled. Thus, these experiments were ideal for studying the effects of serial dependence, when, in fact, no such effects existed by design in the experiments.

Model Description: Each trial was transformed into a vector of task variables. Current and past trial vectors were input into a SANN to predict behavioral metrics for the current trial. An embedding layer was introduced to capture participant-related effects and to accommodate inter-individual behavioral differences (Fig. 3). This enabled training a single model across participants while addressing individual diversity.

Serial Dependence: To isolate the effect of serial dependence, we defined a control condition by shuffling history while keeping the current trial information intact and evaluating the model. Shuffling the history disrupts the effect of serial dependence while maintaining the same number of parameters, which allows for an unbiased comparison between the model's performance under intact and shuffled history conditions. The null hypothesis is that, without serial biases, model predictions with both intact and shuffled histories would be equally good. During shuffling, original history was substituted with trials randomly chosen from the same participant block. This ensured that the structure of the data remained consistent within each participant's experimental block.

Results

Serial dependence in CCD Task

Here, we predict participant's reaction time (RT) on every trial. We used Robust Correlation between predicted and observed RT to measure model's predictive accuracy. Fig. 4 shows the that the model captures strong serial dependence in RT, as evidenced by significantly higher correlations for trials with the intact history as compared to those with shuffled history across all participants. By contrast, we observed no significant serial dependence effects on participants' response accuracies (see Discussion).

Serial dependence in DWM Task: Here, we predict participant's Response Error on every trial, quantified as the circular difference between the probed grating's orientation and the response. We used Circular Correlation (circ. Corr.) between

the predicted and observed Response Errors. Again, we observed strong serial dependence in Response Errors (Fig. 5a) as quantified by the significant decrease in predictive accuracy (circ. Corr) for the model with shuffled history.
Serial dependence in SRM Task: Here, we train one model each to predict participant's RT and Accuracy on every trial. In this case we observed strong serial dependence both in RT (Fig. 5b) and Accuracy (Fig. 5c) as evidenced by the significant decrease in predictive accuracy (robust correlations & AUROC respectively) for the model with shuffled history.

Discussion

Sequence-aware neural networks provide a robust and powerful method to detect the presence of serial dependence in behavioral sequences. Our analyses show that the sequence-aware neural network models effectively capture serial dependence in all three datasets that we tested. This finding indicates that serial dependence exists across various types of cognitive tasks. We employed a validation dataset to select the best hyperparameters and predict on a separate test dataset. As a first step, we used LSTMs as they are known to capture complex temporal relationships. We plan to extend our scope by using Transformers. We plan to use explainability methods (e.g., SHAP) to tease apart different factors affecting serial dependence.
Notably, we do not train models with shuffled histories, rather generate predictions with current trial intact and only shuffle the history. Thus, even in the shuffled history condition, models have access to actual current trial and tend to give significant performance. Moreover, RT predictions were weaker in the SRM task than in the CCD task. Also, serial dependence in Accuracy was strong in the SRM task but absent in the CCD task. We believe that these discrepancies arise from two factors. i) In SRM task, feedback is given to the participants on their accuracy on every trial; this is not the case in the CCD task. ii) In SRM task, subjects are trying to maximize total reward which is dependent largely on their accuracy rather than their reaction time. Future work will additionally test the effects of various cognitive factors like attention and reward manipulations on these serial biases.

**Deep Oscillatory Neural Network (DONN) for solving sequential problems**

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INTRODUCTION

Although mainstream neuroscience models consider either rate code and spike code as two possible forms of neural code, there is a minor school that considers the neural ensemble as the fundamental unit of computation in the brain, and its oscillatory activity as the right level of description of brain dynamics. We have proposed earlier that such oscillatory activity can be modeled like limit-cycle oscillators like the Hopf oscillators, and that networks of such oscillators can be trained using biological plausible learning algorithm to learn arbitrary time multidimensional series. We now extend that work and propose a Deep Oscillatory Neural Network (DONN), akin to the deep neural networks, in which hidden layers consist of either oscillatory neurons or the usual sigmoidal neurons.

METHODS

Oscillators are coupled using power coupling. A single Hopf Oscillator is defined in terms of state variables as

$$\dot{r}_i = \left(\mu - r_i^2\right) r_i + \Sigma_j W_i^j r_j^{\frac{\omega_i}{\omega_j}} \cos\left[\omega_i\left(\frac{\phi_j}{\omega_j} - \frac{\phi_i}{\omega_i} + \frac{\theta_{ij}}{\omega_i \omega_j}\right)\right] + \epsilon I(t)\cos(\phi_i)$$

$$\dot{\phi}_i = \omega_i + \Sigma_j W_i^j \frac{r_j^{\frac{\omega_i}{\omega_j}}}{r_i} \sin\left[\omega_i\left(\frac{\phi_j}{\omega_j} - \frac{\phi_i}{\omega_i} + \frac{\theta_{ij}}{\omega_i \omega_j}\right)\right] + \epsilon I(t)\frac{\sin(\phi_i)}{r_i}$$

where r is the lateral weight connecting oscillators i and j, and theta is a scaling parameter for input I(t). The dynamics of the oscillators are described in the complex domain and learning consists of update the complex-valued weights and the intrinsic frequencies of the oscillators following a gradient descent-type learning algorithm. Since a single Hopf oscillator has resonant property, showing tuned responses to frequencies closed to its intrinsic frequency, DONN may be thought to perform a Fourier-like decomposition of the input signal(s) and apply nonlinear transformations on the same to produce the output signal(s). In this study, the DONN is trained in various signal processing tasks and the details about them is given below.

1) Frequency transformation: the network should generate the desired signal whose frequencies will be a linear transformation of the input signal's frequencies

For example, the for the input  the desired output should be  for positive integer values b and c

2) Filter bank task: network is expected to act as a triangular band-pass filter centred at 3 Hz with spectral bandwidth of 2 Hz to the input signal. Input signals with frequency range from 0.1-10 Hz are used.

3) Even-odd frequency classification task: network should classify whether the frequency of the pure input sinusoidal signal is even or odd

Example: For input , if  is even then desired class is 1 else 0

RESULTS

The network performed accurately in all three tasks, with the mean squared loss less than 0.1. Figure 1 shows the reconstructed signals for frequency transformation and filter-bank tasks, along with the FFT of hidden layer oscillators during filter-bank task.

DISCUSSIONS

In the future, we would like to extend the current model to validate on more difficult sequential problems and showcase that the model is general enough to show all the regimes of biological single and network of neurons.

# How Distinct is Cognitive Science from Psychology?

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Introduction:
Cognitive science is introduced as a multidisciplinary science of the mind. According to the Cognitive Science Society (CSS), the discipline of cognitive science is made up of Artificial Intelligence, Linguistics, Anthropology, Psychology, Neuroscience, Philosophy, and Education ("Cognitive Science Society," 2023). Being an emerging field, influential figures of the field have been introspective about its content and the course of the discipline (e.g., Gardner, 1987; Miller, 2003), including some recent studies which have looked at the field from a bibliometric perspective (Cooper, 2019; Núñez et al., 2019; Schunn et al., 1998).
In the current study, we seek to examine the extent of disciplinary diversity in cognitive science using a bibliometric and a socio-institutional analysis to understand the field in the current times over the last decade. Our analysis goes beyond existing work in scope as, along with the two major flagship journals in cognitive science that were initiated at the start of the discipline (Miller, 2003) — Cognitive Science, Cognition, we analyse the conference proceedings of the CSS . Further, we contrast the analysis with the flagship journal of the Association for Psychological Science, the largest psychological association in the world, Psychological Science.
A bibliometric analysis of the journals Cognitive Science, Cognition, and the conference proceedings of CSS yielded 9386 entries (from 2012 to 2022), while articles from Psychological Science (from 2012 to 2022) yielded 1998 entries. We primarily use the keywords (n = 18603) submitted to the journals by the authors and the affiliation data of the authors from the Scopus database. The affiliation data of authors was utilised for the socio-institutional analysis, which is valuable in understanding the disciplinary backgrounds of the researchers. Keywords and the years allowed us to understand the field's trajectory.

Method:
We do the following pre-processing for the data:
Initial filtering
Filter for articles and reviews while excluding other forms of content, such as editorials.
If there is a plural version of a word (emotion vs. emotions), select that.
Collapse equivalent words. For example, CRT and cognitive reflection → cognitive reflection.
Group keywords into category words. For example, emotions and affect are grouped in affect.
Affiliations
Extract departmental data from listed affiliations.
Collapse equivalent departments. For example, Department of Psychology and Department of Psychological Sciences are grouped into Department of Psychology.
However, we retain distinctions such as Department of Psychological and Brain Sciences as it is not equivalent to Department of Psychology.

Results:
Socio-institutional analysis: Our results primarily show that Departments of Psychology dominate the study of cognition. In the cognitive journals, we found that researchers from psychology departments are the first authors for 57% of articles. The number is slightly lower for the conference, with 50% of all first authors being from Psychology departments. Notably, this is similar to 59% of first authors in Psychological Science being from psychology departments. A Chi-Square test revealed that this difference is not significant ($X2 = 88$, $p = 0.25$). Figure 1 shows the percentage of psychology researchers published in the venues we considered. We consider the case of Computer Science—a founding discipline typically considered a core in cognitive science—to emphasize this overrepresentation. One can note the dismal proportion of publications from computer science departments (see Figure 2). We also find that the promise of education research as an integral part of cognitive science is not realised. In the past decade, education researchers have contributed less than 3% of all the publications. We refrain from statistical tests as the magnitude of the difference is clear.

Bibliometric analysis: Keyword analysis suggests a great overlap between the topics studied by both cognitive science and psychology (see Tables 1-3 for the top ten keywords). Subtraction of keywords used in psychology (Table 1) from cognitive science (Table 2) yields only two distinct words: motivation and perception, while subtracting keywords used in cognitive science (Table 2) from psychology (Table 1) again yields only two distinct words: computational modelling and language acquisition. Thus, even the topics studied in the flagship journals seem to overlap drastically. For the cognitive science conference proceedings, the distinction primarily appears to be methodological, in addition to the language-specific ones. This shows that very similar topics are studied across cognitive science and psychology. Please refer to the Appendix for figures of trends of the keywords.

Discussion:

The current study is built on the previous studies that examined the question of interdisciplinarity in the field (Leydesdorff & Goldstone, 2014) and questioned the common core for cognitive science to be counted as a discipline (Núñez et al., 2019). Our results show a profound overrepresentation of Psychology, which is at odds with the promise of a multidisciplinary field. The findings align with Cooper (2019), who found that more than 50% of submissions made to the journal Cognitive Science are in the area of psychology. It is also possible that cognitive science's core theories, ideas, and assumptions are similar to those of modern psychology when the latter is seen in a broad light (for example, the fifty-four divisions of the American Psychological Association ). The standard introduction of cognitive science constituting six sub-disciplines does not seem to pan out in reality—it is predominantly psychology.

## Normative variations in music perception: Validating PROMS-Mini, a tool for music perception skills

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Introduction:
Musical ability is part of human nature and develops naturally. Music perception skills vary widely in the general population. However, normative variations in music perception skills have not been explored much, as they may have an impact on music education and neuroplasticity induced by music (Kragness & Swaminathan et al., 2021; Swaminathan et al., 2018). Music perception skills include the ability to detect modulations in tone, rhythm, pitch, and melody. Most of the previous work is based on self-reported musical ability. However, an objective assessment could inform us about the individual differences in music perception skills (Law & Zentner, 2012). We investigated normative variations in music perception among a heterogeneous group of participants, including musicians (musically trained) and non-musicians (musically untrained individuals), while also validating (construct and criterion validity) the Profile of Music Perception Skills (PROMS-Mini) in an Indian context. We also examined the differences in music perception skills as a function of instrumental and vocal training.

Methods:
A total of 82 participants (43 males, mean age: 25.3 years; 60 musicians, 22 non-musicians; 34 western instrument players, 19 eastern instrument players, and 30 vocalists) performed PROMS-Mini online including four subtests: Melody (tonal), Tuning (qualitative), Speed and Accent (temporal) (perceptual features of music). In each subtest, a reference stimulus is presented, followed by a repetition and a comparison stimulus. The participants compare the stimuli and report whether they are similar or different. PROMS provides scores on four subtests and four components of music by combining the scores obtained on any two subtests. The components are Sound Perception (melody and tuning), Timing (tempo and accent), Structural (melody and accent), and Sensory (tuning and tempo) (Zentner & Straußß, 2017). PROMS provides a total score which is a linear summation of subtest scores. Such a score may be misleading as one may perform well in certain subtests but not in others. Also, the total score does not reflect the individual contributions of the four perceptual features to music perception. Due to the multicollinearity, PCA was performed using the four subtest-scores (R version 4.3.1), and the Principal Component obtained was named Music Perception. Density plots of perceptual features of music across all participants including musicians and non-musicians were created. Correlation analysis was performed to examine the association between the scores derived from PROMS and Music Perception. An independent sample t-test was performed to find out how the four perceptual features of music vary between musicians and non-musicians, musicians trained in Eastern vs Western instruments, and vocalists. Correlation and Bayesian regression analysis were performed to explore the association between Music Perception and the subtest scores comparing musicians and non-musicians as well as musicians trained in Eastern vs Western instruments.

Results:
Overall, performance on melody, tuning, and accent subtests followed a normal distribution whereas the score on tempo was right-skewed, showing a ceiling effect. The second set of analyses compared the performance of musicians and non-musicians as well as musicians trained in Eastern vs Western instruments. Group comparisons based on the perceptual features of music showed better performance of the musicians only on the Tuning subtest and comparable performance on all the other perceptual features of music (Melody, Tempo, and Accent) compared to non-musicians. In addition, Musicians and Non-musicians showed a comparable dependency on Timing, Structural, and Sensory components whereas musicians showed higher dependency on sound perception (melody + tuning) for perceiving music. The musicians trained in Western Instruments rely more on tonal (melody) and qualitative (tuning) domains whereas those trained in Eastern Instruments rely more on temporal (tempo and accent) domains to perceive music. In addition, vocalists relied more on melody for perceiving music whereas instrumentalists depended more on tempo and accent.

Discussion:
Perceptual features of music such as melody, speed, and accent were found to be comparable across musicians and non-musicians suggesting that musical abilities are not unique to musicians, rather they vary across individuals regardless of musical training. Tempo showed a ceiling effect suggesting that it is a relatively easier subtest of PROMS and is also known to be more deeply embedded and basic to human cognition (Ravignani et al., 2017). The different combinations of the perceptual features, which generate the components do not provide us with more information than the individual perceptual features. Musicians show a higher dependency on sound perception, which can be attributed to tuning as only on this subtest, do musicians perform significantly better than non-musicians. The feature of tuning depends on a culturally specific representation held in long-term memory and therefore may show the effect of musical training (Kunert, Willems & Hagoort, 2016). The components of music not being significant priors of music perception for non-musicians suggests that

musical training may play an important role in providing a structured understanding of perceptual features of music. Musicians trained in Eastern instruments rely more on temporal aspects, whereas Western instrumentalists rely more on the tonal aspects for perceiving music. Perception of elementary aspects of music varies in the general population and as a function of training also validates the utility of PROMS as it focuses on basic aspects of music found across musical systems and traditions.

# Unveiling Gender Dynamics Across Buddhist Non-attachment, Quiet Ego, and Resilience: A Comparative Study on Indian Adults

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Introduction

The concept of 'Non-attachment,' deeply rooted in ancient Buddhist philosophy, underscores the value of relinquishing attachment to transient desires and material possessions, fostering an outlook of impermanence and equanimity towards life (Sahdra et al., 2010). Complementing this, Wayment and Bauer's 'Quiet Ego' theory postulates that individuals with subdued self-centeredness prioritize personal growth and meaningful relationships over self-enhancement (Bauer & Wayment, 2015). In the modern day, we are increasingly getting dependent on external and hedonistic sources of pleasure that provide instant gratification, grappling with rampant materialism and consumerism, egoistic pursuits, and an overload of information through social media. This lifestyle can inadvertently foster attachments to transient external sources of happiness, leading to a higher vulnerability for psychological distress (Twenge, 2014). Therefore, this current study utilizes regression models to examine whether the psychological orientations—Buddhist non-attachment and the quiet ego—can predict psychological resilience in the face of modern challenges and potentially serve as powerful counterbalances to the detrimental effects of the myriad of stressors present today. Especially since societal norms and expectations around gender often influence the ways in which men and women engage with materialism and self-concept. Understanding whether these constructs impact resilience differently across genders could provide valuable insights for tailored interventions aimed at fostering emotional well-being and resilience.

Method

A sample size of 200 (range age: 20-25y, mean age: 20.95y, 100 females) from urban regions of India was collected for this study, using non-probability sampling techniques of purposive and snowball sampling. The inclusion criteria mentioned that participants had to be current residents of India and had completed or were currently enrolled in higher education (either a bachelor's or master's degree). Participants were administered the 'Quiet Ego Scale (QES)' (Wayment and Bauer, 2015) which demonstrated high internal consistency for our sample [Cronbach α: 0.734] . Previous studies have established its good construct and conceptual validity (Wayment and Bauer, 2014). The second scale was 'Non-attachment Scale (NA-7)' (Sahdra et al., 2010) with Cronbach α being 0.734 and has also shown sufficient convergent and discriminant validity previously (Sahdra et. al., 2010). Lastly, the Resilience Scale (RS-14)' (Wagnild and Young, 1993) was administered. It demonstrated very good reliability for our sample, with a Cronbach α 0.858 and has previously shown good validity in collectivistic cultures in other studies (Liu et. al., 2015; Zahid et. al., 2021). SPSS software was used to analyze the data. The predictive power of non-attachment and quiet ego on resilience was calculated by finding out how much of the variance in resilience scores can be explained by non-attachment and quiet ego whilst employing a multiple regression model.

Results

The data was checked for statistical assumptions (linearity, normality, standardized residuals of residuals, homoscedasticity) prior to regression modeling. Since multiple correlations were conducted, we performed Bonferroni corrections to control for the potential of Type I error associated with multiple comparisons. The adjusted p-value came out to be 'p=0.0167' after correction, for the significance set at 'p=0.05'. Quiet ego showed a significant positive correlation with resilience [$r(200)=0.417$, $p<.001$, (adjusted p value)$<0.0167$], as well as non-attachment has a significant positive correlation with resilience [$r(200)=0.564$, $p<.001$, (adjusted p value)$<0.0167$]. The multiple regression model had quiet ego and non-attachment as the independent variables and resilience as the DV. The overall model came out to be significant, $F(2,197) =64.950$, $p<0.001$, explaining 39.7% ($R2=0.397$) of the variance of resilience. Both the predictor variables, quiet ego ($\beta = 0.295$, $p<0.001$) and non-attachment ($\beta=0.487$, $p<0.001$) positively predicted resilience. We can also infer from the standardized beta coefficients that non-attachment influences resilience more than quiet ego. A t-test was conducted to explore gender differences, and it was found that a significant difference was found in non-attachment between males and females [$t(198)=-2.483$, $p<0.05$]. Males had significantly higher non-attachment than females. Additionally, males had significantly higher resilience than females [$t(198)=-2.240$, $p<0.05$]. There were no significant gender differences found for quiet ego.

Discussion

The results of the study suggest that men scored higher on resilience than females. This finding may be attributed to differences in coping strategies and socialization patterns among the two genders. For example, females are more likely to use emotion-focused coping strategies, which may be less effective in promoting resilience (Graves et al., 2021). Additionally, males are socialized to be more independent and self-reliant, which may promote greater resilience in adversity. Rajeev and Hebbani (2020) reveal significant differences between males and females, with males showing

higher resilience in Indian samples, supporting our results. Another potential reason for this result could be owing to the design of the instrument itself, as literature suggests that some resilience scale items might be biased towards masculine presentations of resilience (Hirani et. al., 2016). Historically, men are also encouraged to adopt a stoic demeanour and exhibit emotional restraint, which may foster a sense of detachment from emotional outcomes and situations (Wagstaff et al., 1995). This cultural conditioning might inadvertently encourage the development of non-attachment and resilience in males, as the gendered narratives surrounding resilience encourage traits like emotional strength and self-reliance that represent societal notions of masculinity. Conversely, females may encounter societal pressures to prioritize emotional expression and interpersonal connections, potentially leading to greater attachments to relationships. Females' heightened emotional awareness, empathy, and sense of compassion could engender a greater investment in emotional ties, possibly conflicting with the concept of detachment from people and situations around them. Finally, sample composition, measurement limitations, and cultural shifts towards self-awareness might lead to the absence of discernible gender differences in the expression of the quiet ego trait. In conclusion, this study offers an empirical bridge between age-old wisdom and contemporary psychological theory by investigating the role of Buddhist non-attachment and quiet ego in resilience and acts as a starting point for researchers to uncover mechanisms underpinning such intriguing psychological processes.