The Attraction Effect in Perceptual Decision-Making: A Case of Dominance Asymmetry

Tapas Rath[1], Narayanan Srinivasan[1], and Nisheeth Srivastava[1]

[1]Indian Institute of Technology Kanpur India

Affiliation

Author Note

Tapas R. Rath https://orcid.org/Journal of Experimental Psychology: General

Correspondence concerning this article should be addressed to Tapas R. Rath, Department of Cognitive Science, Indian Institute of Technology Kanpur, Kanpur 208016, INDIA. E-mail: rathtapasiitk@gmail.com

Abstract

The attraction effect (AE), or asymmetric dominance effect, is a well-established context effect in decision-making, wherein the introduction of a clearly inferior decoy option increases preference for a target over a competitor. While robustly demonstrated with value-based and numerical stimuli, recent studies have reported inconsistent or even reversed AEs when using perceptual stimuli, especially in non-linear (triangular) arrangements, challenging the effect's domain generality. This study aimed to resolve these inconsistencies by examining whether the presence or absence of true dominance asymmetry in the decoy underlies these divergent findings. Across three experiments, we first validated a novel star-shaped perceptual stimulus set that reliably produced strong dominance asymmetry in pairwise comparisons, in contrast to traditional rectangle stimuli. Using these star stimuli in a triplet-choice task with a triangular arrangement, we observed a robust positive attraction effect, marking the first such demonstration with perceptual stimuli in this configuration. In contrast, traditional rectangle stimuli produced only a weak, non-significant effect. Our results support an item-based, rather than strictly attribute-based, definition of asymmetric dominance and suggest that the magnitude of the attraction effect in perceptual decision-making is mediated by the dominance asymmetry of the decoy in pairwise comparisons. These findings clarify the boundary conditions for observing the AE with perceptual stimuli and reinforce the effect's domain generality when dominance asymmetry is properly implemented.

Keywords: Preference reversals, attraction effect, asymmetric dominance

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General Introduction

A widely studied choice bias in decision-making is the ‘attraction effect’ (AE) or ‘asymmetric dominance effect’, where the presence of a third option (the ‘decoy’: D) influences decision-makers to prefer one of the original options (the ‘target’:T) over the other (the ‘competitor’:C). The phenomenon is practical and important as a behavioral nudge to influence consumers’ choices. It is theoretically important since it demonstrates a violation of an assumption in rational choice theory: regularity. The attraction effect has been observed in a wide range of domains in the last four decades, including risky decision making (Farmer et al., 2017), inference (Choplin & Hummel, 2005; Trueblood, 2012), consumer choices (Huber et al., 1982; Noguchi & Stewart, 2014), and motor planning (Farmer et al., 2017). Studies in developmental psychology and behavioral ecology have further revealed that this effect extends beyond human adults, affecting children (Zhen & Yu, 2016), cats (Scarpi, 2011), monkeys (Parrish et al., 2015), hummingbirds (Bateson et al., 2003), frogs (Lea & Ryan, 2015), honeybees (Shafir et al., 2002), and even slime molds (Latty & Beekman, 2011). Studies by Choplin and Hummel (2005) and Trueblood et al. (2013), which demonstrated AEs even in the perceptual domain, became essential milestones in establishing the ubiquity of the effect and challenging the possibility of cardinal representations of value in the brain.

Despite its wide documentation across species and domains, recent years have seen a growing number of studies reporting inconsistent, muted, or even reversed attraction effects (Frederick et al., 2014; Yang & Lynn, 2014). More recently, however, Huber et al. (2014) identified several boundary conditions that can constrain the effect: strong prior preferences between core options, difficulty detecting dominance, individual variation in attribute weighting, and pronounced aversion to or preference for the decoy. They argued that studies failing to meet one or more of these criteria unsurprisingly reported inconsistent effects.

Subsequently, in the perceptual domain, Spektor et al. (2018, 2022) found reversed effects when stimuli were arranged in a triangular configuration, leading some to question the domain generality of the attraction effect. We suggest that these recent failures may reflect the violation of an additional, previously overlooked boundary condition: the requirement that the decoy be truly asymmetrically dominated. Building on a pairwise comparison framework common in the choice literature, we developed a novel class of perceptual stimuli that afford clear and unambiguous asymmetric dominance, allowing us to test whether restoring this relational structure reinstates the standard attraction effect.

Decades of research on sequential sampling models for multi-alternative, multi-attribute choice indicate that information is processed sequentially, with attention shifting to compare and evaluate subsets of options throughout the deliberation process (Roe et al., 2001; Usher & McClelland, 2004). Prominent models of choice (Evans et al., 2021; Kornienko, 2013; Noguchi & Stewart, 2018; Ronayne & Brown, 2017; Russo & Dosher, 1983; Trueblood et al., 2014; Wollschläger & Diederich, 2012) assume that this subset is a pair—pairwise comparisons are at the heart of these models. Eye-tracking studies (Noguchi & Stewart, 2014) also suggest that alternatives are compared in pairs, often along a single attribute dimension. Similarly, the ordinal comparison model proposed by Srivastava and Schrater (2015) is based on pairwise comparisons. We adopt this last model because it offers a simple account of the attraction effect, explicitly incorporating the decoy's dominance asymmetry into the decision process. According to the model, an option gains in overall value by winning more pairwise comparisons via simple vote counts. When the decoy is clearly inferior to the target, it is easily dominated by it. However, when comparing the target and competitor, decision-makers are often indifferent. In such cases, for the target to win the final vote count, the competitor–decoy comparison should not clearly favor the competitor. That is, the decoy must be asymmetrically dominated—it should be dominated by the target but not by the competitor.

This raises a further issue regarding how asymmetry is defined. Over the years, the notion of asymmetry in the context of the attraction effect has become closely associated with an attribute-based definition. According to this widely adopted view, an asymmetrically dominated decoy is an option that is inferior to the target on all attributes but only partially dominated by the competitor—that is, along at least one attribute, the decoy is better than or equal to the competitor (Bhatia, 2013; Helgadóttir, 2015; Kaptein et al., 2016; Zofák, 2016). For example, Bhatia (2013) state that the decoy is dominated by the target in both attributes but "better" than the competitor in one attribute. Similarly, Kaptein et al. (2016) define an asymmetrically dominated decoy as "an option, which is completely dominated by the target on at least one attribute, and where the decoy itself does not possess an attribute that is superior to the target." This attribute-based view has informed the design of many experimental studies.

However, the original definition from Huber et al. (1982, p. 90) is item-based rather than attribute-specific: "An asymmetrically dominated alternative is dominated by one item in the set but not by another." That is, the focus is on overall dominance relations between entire options, not necessarily on component-wise comparisons. In this work, we adopt this item-based definition, which aligns with the pairwise comparison account outlined earlier. Figure 1 shows the placements of the items in the attribute space for the AE.

Based on this reasoning, we hypothesized that many of the perceptual tasks showing weak or reversed attraction effects may have inadvertently used decoys that were not clearly asymmetrically dominated. To test this, we designed a new class of perceptual stimuli—star shapes—that more reliably establish asymmetric dominance at the item level. Experiment 1 tested the dominance asymmetry of this new stimulus set by comparing it with a traditional rectangle stimulus set that previously showed a reversed effect (Spektor et al., 2018). Participants made binary choices between a target and a decoy (TD pair), or between a competitor and a decoy (CD pair). In Experiment 2, we tested the new stimuli for the attraction effect using a triplet-triplet design. Finally, in Experiment 3, we attempted to replicate the earlier reversed effect with rectangles and predicted a reduced or muted attraction effect.

Experiment 1

Introduction

In the pre-registered within-subjects experiment 1, we used two independent variables—stimulus type (rectangle vs. star) and comparison pair (CD vs. TD). We predicted a significant interaction effect on the dependent variables of accuracy and reaction times. In addition, we collected perceived difficulty ratings of choice (exploratory) when alternatives were compared in pairs.

Method

Participants

Sixty-seven university students with normal or corrected-to-normal vision, aged 18–25 years, participated in the study.

Apparatus and Stimuli

The experiment was designed using JavaScript and conducted on laboratory computers with screen resolutions of 1920 px $\times$ 1080 px. Stimuli were presented in pairs (target-decoy pairs and competitor-decoy pairs), aligned horizontally, and consisted of two types of shapes: rectangles and star-like shapes. In each trial, the stimuli consisted of two horizontally aligned black-colored shapes on a white background. The vertical positions of the stimuli were jittered across trials. The stimulus pair for each trial was derived from the respective set of triplets. In each trial, either a target-decoy pair or a competitor-decoy pair was displayed.

Rectangle Stimulus. Following Spektor et al. (2018), one set of rectangles was created using a bivariate normal distribution with a mean height of 170 pixels and a mean width of 250 pixels. The variance for each attribute was 25 pixels, and there was no correlation between the variances, allowing for variability in the task. A second set of rectangles had the same values and matched in area but were vertically oriented instead of horizontally. One of these sets was considered the target, while the other was the competitor.

The third set (i.e., decoy rectangles) was created such that, in the attribute space, it was placed close to one alternative for half the trials and close to the other alternative for the remaining half. This followed the triplet-triplet design by Wedell (1991). We included all three types of decoys: range, frequency, and range-frequency decoys (Huber et al., 1982).

Star Stimulus. Each star-like shape was derived from a base rectangle, with four distinct sections removed. These sections consisted of two pairs of inward-facing isosceles triangles, where the bases of the triangles were equal to and touched the four sides of the rectangle, resulting in a star-like shape.

The shape characteristics were determined by two key parameters: the base rectangle's width and the height of the removed triangles. Specifically, for the first out of the two sets of core stimuli, the mean rectangle width (μ_{w_1}) was set to 180 px, while the mean triangle height (μ_{d_1}) was set to 40 px. The respective variances were 30 px ($\sigma^2_{w_1}$) and 40 px ($\sigma^2_{d_1}$), with no correlation between the two.

Additionally, the height H_1 for the shape was determined by adding a random adjustment to the width. This adjustment was drawn from a normal distribution with a mean of 20 px and a standard deviation of 5 px. The value of H_2, representing the second height, was set equal to H_1.

The participants were instructed that the shapes represented objects drawn with sand, and their task was to identify which of the given shapes would require the least amount of extra colored sand to be extended into a perfect square. Of the two core shapes, one had a wider base rectangle and a larger removed triangle height, while the other had a narrower base rectangle and a proportionally smaller removed triangle height. For simplicity, we refer to the wider shape as “W” (wide) and the narrower shape as “N” (narrow).

To generate the stimuli, the W shapes were created first using the width and height distributions mentioned above. Then, ensuring that both W and N shapes required the same amount of extra area to form a perfect square, the N shapes were derived.

As with the rectangular shape, the third set (i.e., decoy shapes) was created such that, in the attribute space, it was placed close to one alternative and made inferior to it for half the trials and close to the other alternative and made inferior to it for the remaining half. We included all three types of decoys: range, frequency, and range-frequency decoys (Huber et al., 1982).

Before the main experiment, each participant completed a feedback-based practice session where they were presented with 10 pairs of shapes in random order. In five trials, the W stimulus was the expected answer, and in five trials, the N stimulus was the expected answer. Participants could click on each black shape to transform it into a perfect square, with the extra-filled portion highlighted in red. When a shape was clicked, a numerical value representing the extra sand required (e.g., 21,458 units) appeared below the shape in an arbitrary unit of measurement. The practice session was to ensure that participants understood the task instructions, especially for the star task.

Procedure

The experimental conditions were defined by two independent variables: (1) Stimulus Type (rectangle vs. star), and (2) Comparison Pair (Target-Decoy [TD] vs. Competitor-Decoy [CD]). Each participant experienced all four combinations of these variables: (1) Rectangle, CD, (2) Rectangle, TD, (3) Star, CD, and (4) Star, TD.

The trials were presented using block randomization to ensure balanced exposure to all conditions. The experiment consisted of 12 blocks, each containing one trial per condition. Each condition was presented 12 times, resulting in 48 experimental trials. The Fisher-Yates algorithm was applied to randomize the order of conditions within each block, ensuring that the sequence of trials was unpredictable while maintaining balance. Additionally, 12 catch trials were included as exclusion criteria and were randomly interspersed throughout the experiment. The catch trials were distributed across the trial sequence using the same randomization method, ensuring a unique and unbiased presentation for all participants.

For rectangle trials, participants were instructed to select the rectangle with the largest area. For trials with star-like shapes, they were instructed to choose the shape requiring the least amount of additional colored sand to extend it into a perfect square. Participants selected the alternative in each trial using the left or right arrow keys. Following their decision, using number keys 1-7, they rated the difficulty of their choice on a 7-point Likert scale, where one represented "extremely easy" and seven represented "extremely difficult." On average, participants completed the experiment in approximately 15–20 minutes.

Results and Discussion

Out of a total of 67 participants, we excluded data from 6 participants because their performance was lower than 0.8 in the catch trials, where in each trial, there was clearly one best option out of the two. Additionally, we excluded a total of 119 individual trials (4.05%) that were either too fast (<100 ms) or too slow (>20,000 ms).

We performed repeated measures ANOVAs on accuracy, reaction time, and perceived difficulty ratings. The interaction effects of *Stimulus Type* (Star vs. Rectangle) × *Comparison Pair* (CD vs. TD) on all three were significant. ANOVA results are in Table 1. Interaction plots are shown in Figure 2. The main effects of the pair were significant for difficulty rating, accuracy, and RT. On average, the CD pair was rated as more difficult than the TD pair, and performance (both accuracy and RT) was better for the TD pair than the CD pair. Similarly, the main effects of stimulus type were also significant for accuracy and RT. Performance for rectangular stimuli (both RT and accuracy) was better compared to star stimuli. However, considering both the stimulus type and the comparison pair interaction, the pattern of results diverged between the stated difficulty and the revealed difficulty (as measured by accuracy), as well as RT.

Using accuracy as a proxy for decoy's dominance, the results support our hypothesis regarding the asymmetry of dominance, at least in the pair-wise comparisons. In the post hoc analysis, the accuracy difference between the two pairs was significant for the star stimuli ($t(60) = 7.069$, $p < 0.001$, Cohen's $d = 1.017$, mean difference = 0.180, SD = 0.199). In contrast, the TD CD accuracy difference for rectangle stimuli, while still significant, was notably smaller ($t(60) = 5.118$, $p < 0.001$, Cohen's $d = 0.579$, mean difference = 0.085, SD = 0.130).

The interaction effect in the accuracy results suggests that the decoy's dominance asymmetry was strong for star stimuli but less pronounced for rectangle stimuli. To rule out the possibility that these results were influenced by a baseline preference bias for either wide (W) or narrow (N) core options, we fit a linear mixed-effects model including target type and its interaction with pair type. The interaction was not significant ($p = .54$), confirming that the dominance asymmetry was robust across both W and N targets (see Appendix A for full details).

Surprisingly, for self-reported difficulty and RT, there was a difference between CD and TD only with rectangular stimuli. It is not clear why the less accurate star stimuli do not show a significant difference in RT and perceived difficulty between the CD and TD pairs.

Experiment 2

Introduction

Building on the findings of Experiment 1, which demonstrated stronger asymmetric dominance using star-shaped stimuli in a pair-wise comparison task, Experiment 2 examined whether this asymmetry would generalize to a full triplet-choice context. Assuming pair-wise item comparison as the underlying cognitive mechanism driving the attraction effect, it follows that stimuli exhibiting strong dominance asymmetry in dyadic judgments should also produce a robust attraction effect when embedded within a triplet choice set. We therefore hypothesized that our novel star-shaped stimuli would elicit a reliable attraction effect even when arranged in a triangular format, as is standard in decoy paradigms. In contrast, the traditional rectangle stimuli (e.g., those used by Spektor et al., 2018), which showed weaker dominance asymmetry in Experiment 1, were not expected to yield a comparably strong attraction effect—a prediction further tested in Experiment 3.

Method

Participants

Fifty-four students with normal or corrected-to-normal vision, aged 18–25 years, participated in the study.

Apparatus and Stimuli

The experiment was designed using JavaScript and conducted on similar laboratory computers. In each trial, the stimuli consisted of three different black-colored star shapes on a white background. These shapes were arranged randomly in a triangular formation around the center of the screen, with their vertical positions jittered across trials.

The star-like shapes were constructed following the method used in Experiment 1. Each star-like shape had the width of the base rectangle and the height of the removed triangles as its two attributes. In addition to the transition from pair to triplet comparisons, Experiment 2 incorporated a bias correction that distinguished it from Experiment 1. A pilot study revealed a systematic preference among participants for the wider (W) shape. To counteract this bias in the main experiment, the computed width of the narrower (N) shape—denoted as w_2 — was increased by 10 pixels. This adjustment aimed to equalize the perceptual appeal of the stimuli and ensure a more balanced choice distribution. Similar to Experiment 1, each participant completed a feedback-based practice session with 10 trials before the main experiment.

Procedure

Participants were instructed to determine which of the three shapes required the least amount of extra colored sand to extend into a perfect square. In each trial, participants made their selection using arrow keys and proceeded to the next trial using the space bar. During the practice session, participants were provided feedback after each selection to help familiarize them with the task. This study was not preregistered.

Results and Discussion

Data were collected from 54 participants. Two participants were excluded for failing to meet the predefined accuracy threshold of 0.8 on catch (filter) trials. In addition, ten participants were excluded due to a technical error that resulted in missing response time (RT) data for the majority of their trials; for these participants, only the first 10 trials contained RT data, while the remaining 170 trials were missing. This left a total of 42 participants for subsequent analyses.

Within the retained sample, individual trials were further excluded if the RT was less than 100 ms or exceeded a participant-specific upper threshold, defined as the 75th percentile plus 1.75 times the interquartile range of that participant's RT distribution. After applying these criteria, a total of 522 trials (representing 6.9% of all trials) were excluded, resulting in 7038 valid trials (93.1% of the total) available for analysis.

We quantified context effects using the equal-weights version of *Relative Choice Share of the Target* (RST) (Katsimpokis et al., 2022). RST measures how often the target is chosen over the competitor, with 0.5 indicating the absence of a context effect. RST is computed as:

$$RST_{\text{EW}} = \frac{1}{2}\left(\frac{T_X}{T_X + C_X} + \frac{T_Y}{T_Y + C_Y}\right)$$

Here, T_X and C_X are the number of target and competitor selections, respectively, when the decoy favors option X, and T_Y and C_Y are the corresponding counts when the decoy favors option Y. An RST value above 0.5 suggests a positive attraction effect, and values below 0.5 indicate a reversed effect.

A two-tailed t-test was performed to compare the RST values against the null value of 0.5. The mean RST ($M = 0.536$, $SD = 0.050$) was significantly higher than the null value of 0.5; $t(41) = 4.683$, $p < 0.001$, Cohen's $d = 0.723$. To complement the frequentist analysis, a Bayesian one-sample t-test was also conducted using the default Jeffreys–Zellner–Siow (JZS) prior with a scale parameter $r = 0.707$. The resulting Bayes factor indicated strong evidence for the alternative hypothesis over the null ($\mathrm{BF}_{10} = 702.822$), suggesting the data are approximately 703 times more likely under the alternative hypothesis than under the null. Figure 3 shows two example trials and the overall distribution of the choice share in the two contexts. Figure 4 depicts a corresponding violin plot for the overall RST values. To our knowledge, this study is the first to demonstrate the positive AE for perceptual stimuli arranged in a triangle.

Experiment 3

Introduction

While previous studies using traditional stimuli have reported a negative attraction effect—where the presence of a decoy decreases preference for the target option (e.g., Spektor et al. (2018))—we predicted a non-negative, albeit modest, attraction effect with the same stimuli. This prediction was grounded in the results of Experiment 1, which revealed a weak but statistically significant dominance asymmetry even for the traditional rectangle set under pair-wise comparison. If the attraction effect indeed reflects underlying item-based dominance relations, then even a limited asymmetry should yield a small but positive attraction effect in a triplet context. Experiment 3, therefore, aimed to replicate the findings from Experiment 4b in Spektor et al. (2018) using their original stimuli and design, while testing our prediction that the attraction effect would not reverse but would instead be attenuated or near zero.

Method

Participants

Seventy-six volunteers with normal or corrected-to-normal vision, aged 18–25 years, participated in the experiment.

Apparatus and Stimuli

This experiment was also designed using JavaScript and conducted on similar laboratory computers. The rectangle stimuli were created following a similar procedure to that used in Experiment 1. The decoy creation method, including range, frequency, and range-frequency decoys, remained consistent with Experiment 1.

Procedure

In each trial, participants were instructed to select one of the three rectangles with the largest area, presented in a triangular formation. This study was not preregistered.

Results and Discussion

Of the 76 participants tested, two were excluded due to a technical error that prevented complete reaction time (RT) logging. An additional six participants were excluded for performing below the predetermined accuracy threshold (i.e., less than 80%) on catch trials.

At the trial level, responses with implausible RTs were excluded. Specifically, trials with RTs below 100 ms or exceeding a participant-specific upper threshold defined as the 75th percentile plus 1.75 times the interquartile range (IQR) were removed. This procedure led to the exclusion of 647 trials, representing approximately 5.87% of the total data and resulted in 10371 valid trials (94.13% of the total) available for analysis.

We performed a two-tailed one-sample t-test on overall RST. We were unable to replicate the negative AE reported in previous studies; rather, we found that overall RST ($M = 0.501$, $SD = 0.054$) was not significantly different from the null (0.5); $t(67) = 0.224$,

$p = 0.823$, Cohen's $d = 0.027$. To further quantify the evidence, we conducted a Bayesian one-sample t-test using the default Jeffreys–Zellner–Siow (JZS) prior with a scale parameter $r = 0.707$. The Bayes factor (BF_{10} = 0.14) indicated that the data were about seven times more consistent with the null hypothesis than with the alternative.

General Discussion

This study investigated the attraction effect (AE) in perceptual decision-making, particularly addressing inconsistencies in recent literature where standard attraction effects were muted or reversed when perceptual stimuli were arranged in a triangular formation. Across three experiments, we demonstrated that the effectiveness of decoys in producing the attraction effect depends critically on their dominance asymmetry—specifically, whether they are truly dominated by the target but not by the competitor. Our novel star-shaped stimuli successfully produced a significant positive attraction effect even in triangular arrangements, contrasting with previous findings of negative effects using traditional rectangular stimuli. These results support an item-based definition of asymmetric dominance and highlight the importance of pairwise comparisons in multi-alternative decision-making.

Summary of Findings

Experiment 1 established that our novel star-shaped stimuli demonstrated stronger dominance asymmetry compared to traditional rectangular stimuli when evaluated in pairwise comparisons. The significant interaction effect between stimulus type and comparison pair on accuracy provided empirical support for our hypothesis that dominance asymmetry varies across stimulus types. Specifically, participants showed a greater accuracy difference between target-decoy (TD) and competitor-decoy (CD) pairs for star stimuli compared to rectangle stimuli, suggesting more pronounced asymmetric dominance with the star stimuli. Supplementary analyses confirmed that this asymmetry was not attributable to a baseline preference bias for either core option (see Appendix A).

Building on these findings, Experiment 2 demonstrated a robust positive attraction effect when using our novel star stimuli arranged in a triangular formation. This is, to our knowledge, the first demonstration of a positive attraction effect with perceptual stimuli in a triangular configuration—a setup that had previously yielded negative effects in the literature. The results suggest that the dominance asymmetry observed in pairwise comparisons in Experiment 1 successfully translated to a robust attraction effect in the full triplet context.

In Experiment 3, we attempted to replicate previous findings of negative attraction effects with traditional rectangular stimuli. However, contrary to previous reports, we observed a non-significant effect. This result aligns with our prediction based on Experiment 1, where rectangular stimuli showed weaker, though present dominance asymmetry in pairwise comparisons.

Theoretical Implications

Our findings have several important theoretical implications for understanding the attraction effect and decision-making processes more broadly. First, they provide strong support for the item-based definition of asymmetric dominance originally proposed by Huber et al. (1982). While much of the subsequent literature has adopted an attribute-based definition focused on specific attribute comparisons, our results suggest that the original, more general item-based conceptualization better captures the conditions necessary for producing the attraction effect.

Second, our results help resolve apparent contradictions in the literature regarding the domain generality of the attraction effect. The failure to observe positive attraction effects in perceptual tasks with triangular arrangements (Spektor et al., 2018, 2021) had called into question whether the effect generalizes beyond higher-level decision domains. Our successful demonstration of a positive effect with perceptually complex stimuli suggests that the attraction effect is indeed domain-general, but contingent upon proper implementation of asymmetric dominance.

Methodological Contributions

This study makes several methodological contributions to the field of decision-making research. We introduced a novel perceptual stimulus—the star-shaped figure—that effectively creates conditions for asymmetric dominance. This stimulus design offers researchers a new tool for investigating the attraction effect in perceptual domains while maintaining the critical feature of dominance asymmetry. The effectiveness of this stimulus derives from its complex perceptual properties that require integrating multiple visual features, thereby creating conditions where dominance relationships between alternatives become more pronounced.

Our methodological approach also demonstrates the importance of verifying dominance asymmetry at the pairwise level before implementing decoy paradigms. Experiment 1's design, directly comparing accuracy in TD versus CD pairs, provides a template for researchers to validate stimulus sets before conducting full attraction effect experiments. This validation step may be particularly valuable when working with perceptual stimuli where dominance relationships may be less intuitive than in value-based decision-making.

Additionally, our direct comparison of different stimulus types within the same experimental paradigm (Experiment 1) provides a controlled demonstration of how stimulus properties influence dominance asymmetry and, consequently, the attraction effect. This comparative approach could be extended to other types of stimuli to further map the boundary conditions of the effect.

Limitations and Future Directions

Despite the clear pattern of results across our experiments, several limitations should be acknowledged. First, while our novel star stimuli successfully produced dominance asymmetry and a positive attraction effect, the specific properties that make these stimuli effective remain somewhat underspecified. For example, a stronger dominance asymmetry could itself be a result of attribute incommensurability (Hayes et al., 2024; Walasek & Brown, 2023). Future research could systematically vary stimulus properties to identify precisely which features are critical for creating effective asymmetric dominance in perceptual tasks.

Second, the cognitive mechanisms underlying the translation from pairwise dominance judgments to triplet choices require further investigation. While our results are consistent with sequential sampling models that emphasize pairwise comparisons, direct process measures such as eye-tracking or mouse-tracking in a triplet context could provide more detailed insights into how these comparisons unfold during decision-making with perceptual stimuli.

Third, given our results, one might question why stimuli, with a low asymmetric dominance of the decoy, arranged linearly, did Trueblood et al. (2013) observe a standard AE, later replicated by Spektor et al. (2018). Although this remains to be explored in future studies, first, we highlight that a linear arrangement of stimuli could have introduced other biases in eye movements (e.g., transitions between two options next to each other are easier than between the outer options) and choices (Spektor et al., 2022). Second, attention might play out differently in a linear arrangement, driving the positive effect there. For example, the matched orientation of the stimuli in a linear arrangement could make the target-decoy pairs consistently salient, regardless of their position in a trial, leading to overall positive effects. This assumption is reasonable. In fact, the Multi-attribute Linear Ballistic Accumulator (MLBA) model (Evans et al., 2019; Trueblood et al., 2014; Turner et al., 2018) makes a similar assumption to explain the same positive effect. According to the MLBA, preference for an option is calculated as a weighted sum of pairwise comparisons with other options in the choice set. The weights in the model, which serve as a proxy for attention, are based on the similarity of the attributes being compared, with greater weight placed on similar attributes. When a decoy, similar yet inferior to the target, is introduced, more weight is assigned to this difference. Consequently, comparisons between the target and decoy (which favor the target) are given more weight in calculating preference, leading to the target being chosen more frequently and resulting in the attraction effect.

In addition to the directions noted above, several further avenues for future research emerge from our findings. Researchers could extend our approach to other perceptual domains (e.g., auditory, tactile) to further test the domain generality of the attraction effect. Computational modeling could formalize the relationship between dominance asymmetry in pairwise comparisons and the resulting attraction effect in triplet choices. Neuroimaging studies could investigate whether the neural mechanisms underlying the attraction effect with our novel stimuli are similar to those involved in more traditional value-based decision contexts.

Conclusion

This research resolves an apparent contradiction in the literature regarding the attraction effect in perceptual decision-making. By introducing a novel stimulus designed to produce stronger dominance asymmetry, we demonstrated that the attraction effect can be observed in perceptual tasks, even with triangular arrangements that previously yielded negative effects. Our findings support an item-based definition of asymmetric dominance and highlight the critical role of pairwise comparisons in multi-alternative decision-making.

More broadly, this study contributes to our understanding of the cognitive mechanisms underlying context effects in decision-making. The attraction effect—initially discovered in consumer choice contexts—appears to reflect fundamental properties of information processing that extend across domains. When proper conditions of dominance asymmetry are met, the effect emerges consistently across varied decision scenarios, from consumer choices to perceptual judgments.

By establishing the conditions under which the attraction effect reliably appears in perceptual decision-making, our research provides both theoretical clarity and methodological guidance for future investigations of this robust but sometimes elusive decision bias. The successful demonstration of the effect with our novel stimuli suggests that perceptual decision-making may be subject to the same context-dependent biases as in the preferential domain, supporting a unified framework for understanding human choice behavior across domains.

Table 1

Repeated Measures ANOVA Results for Accuracy, Reaction Time, and Difficulty Rating

Factor	$F(1,60)$	p	η_p^2
Accuracy			
Stimulus type	11.160	.001	.157
Pair	75.767	$< .001$	.558
Stimulus type × Pair	9.813	.003	.141
Reaction Time			
Stimulus type	26.725	$< .001$	.308
Pair	9.422	.003	.136
Stimulus type × Pair	4.494	.038	.070
Difficulty Rating			
Stimulus type	2.478	.121	.040
Pair	22.623	$< .001$	.274
Stimulus type × Pair	8.634	.005	.126

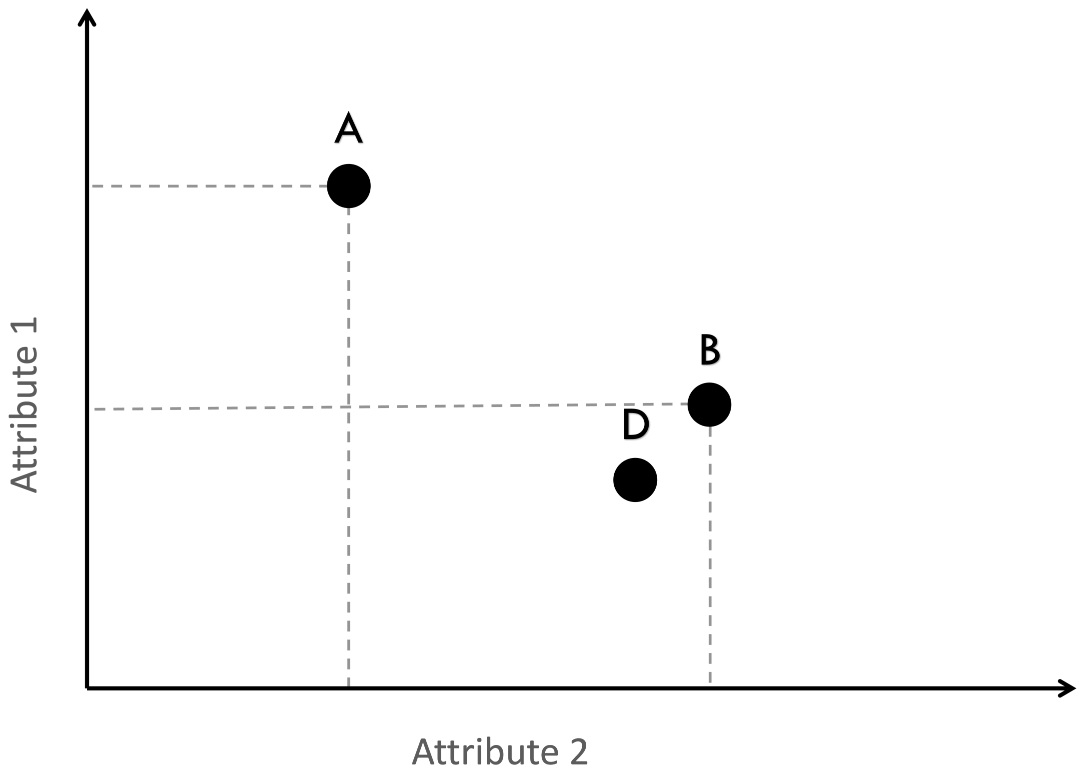

Figure 1

Asymmetric Dominance Effect

Note. Here B is the target, A is the competitor, and D is the decoy. The choice share of alternative B increases with the introduction of decoy D, which is dominated by B but not by A.

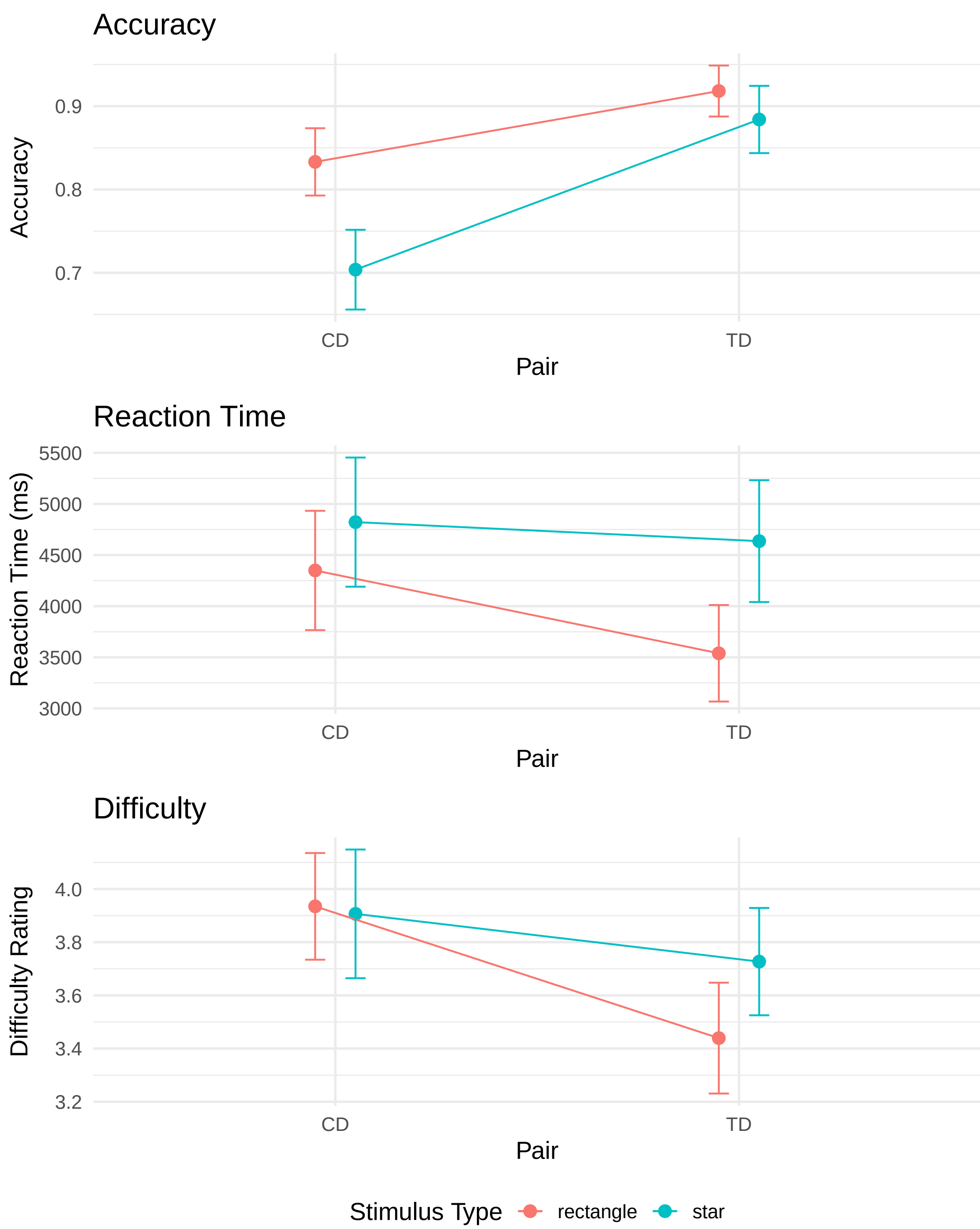

Figure 2

Interaction Effects of Stimulus Type and Pair on Accuracy, Reaction Time, and Difficulty

Note. Error bars represent 95% within-subject confidence intervals.

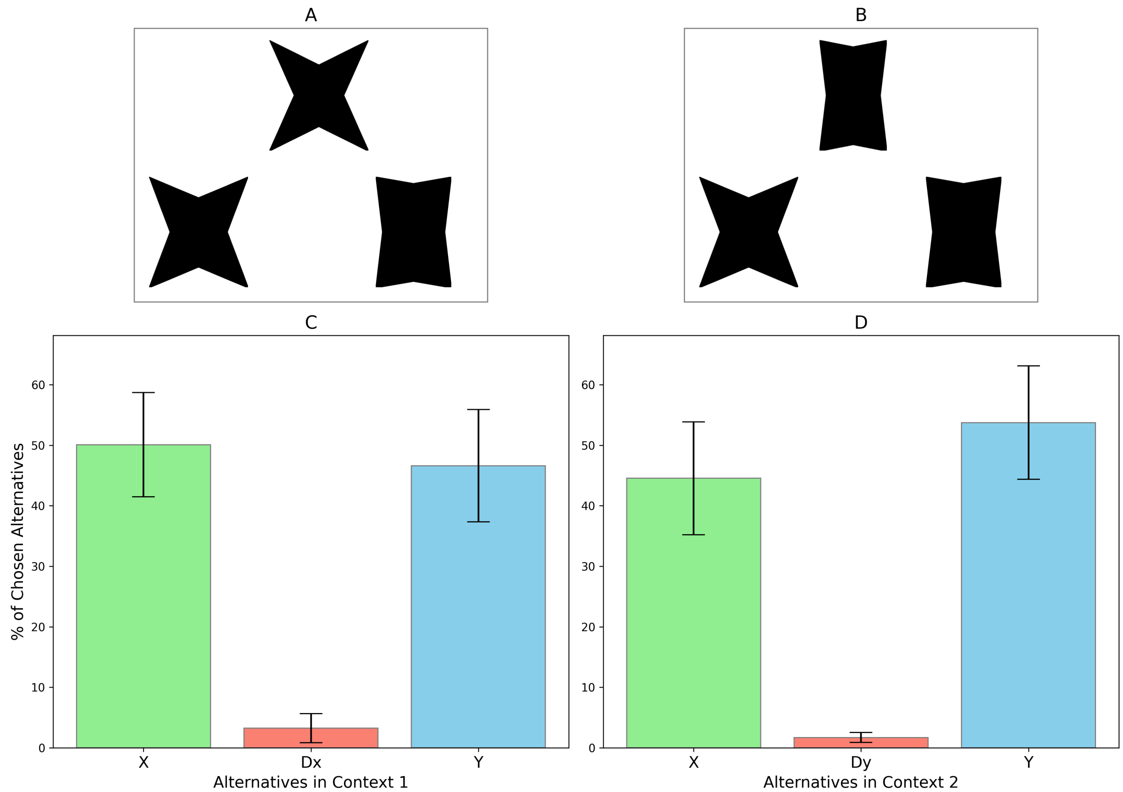

Figure 3

Example Trials and Choice Shares in Experiment 2

Note. Panel A shows a trial with the wider stimulus as the target, while Panel B shows the narrower stimulus as the target. Panels C and D display choice shares for two contexts, with X and Y as core options and Dx and Dy as decoys favoring X and Y, respectively. Error bars are 95% confidence intervals.

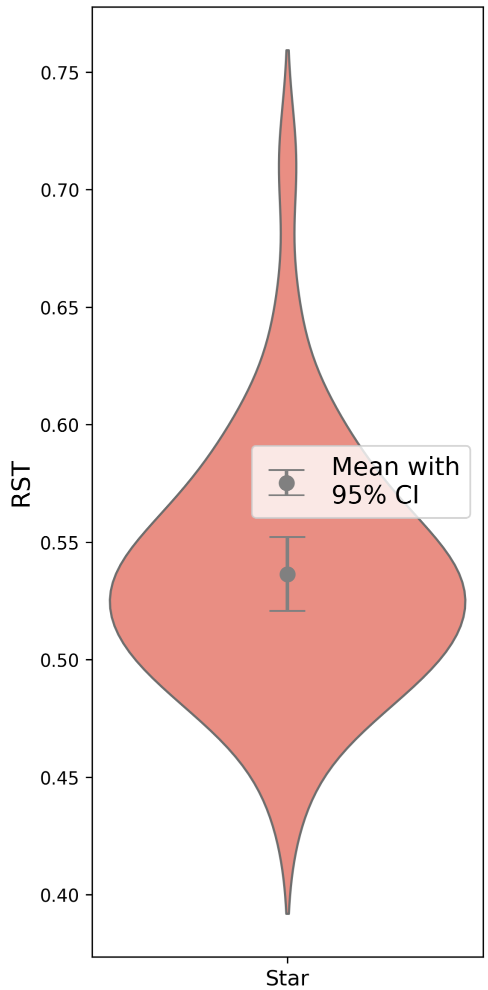

Figure 4

Response Selection Time in Experiment 2

Note. Error bars represent 95% confidence intervals.

Appendix

Baseline Preference Check in Experiment 1

To ensure that the observed dominance asymmetry in Experiment 1 was not confounded by a baseline preference for either the wide (W) or narrow (N) core option, we conducted a generalized linear mixed-effects model (GLMM) analysis. The model predicted trial-level accuracy (correct/incorrect) with fixed effects of pair type (target-decoy [TD] vs. competitor-decoy [CD]), target type (W vs. N), their interaction, and stimulus type (rectangle vs. star). A random intercept for participant was included to account for repeated measures.

Model specification

The GLMM was fitted using the binomial family with a logit link. The formula in `R` notation was:

```
correct ~ pair * target_type + stimulus_type + (1 | userId)
```

where `correct` is a binary variable (1 = correct, 0 = incorrect), `pair` is TD or CD, `target_type` is W or N, `stimulus_type` is rectangle or star, and `userId` is the participant identifier.

The analysis included 2,817 trials from 61 participants. The random effect variance for participant intercepts was 0.45 (SD = 0.67). Model fit indices were AIC = 2,339.9 and BIC = 2,375.6.

Results

Table A1 summarizes the fixed effects estimates. The main effect of pair type was significant, with higher accuracy for TD pairs than CD pairs (odds ratio = 3.15). There was no significant main effect of target type (W vs. N; $p = .96$), indicating no overall baseline preference for either option. Critically, the interaction between pair type and target type was not significant ($p = .54$), demonstrating that the accuracy difference

[t]

Table A1

Fixed Effects Estimates from the GLMM Predicting Accuracy in Experiment 1

Predictor	Estimate	*SE*	*z*	*p*	OR
(Intercept)	1.67	0.14	11.58	$< .001$	5.30
Pair TD	1.15	0.16	7.11	$< .001$	3.15
Target type W	-0.01	0.13	-0.05	.96	0.99
Stimulus type star	-0.66	0.11	-6.08	$< .001$	0.52
Pair TD $\times$ Target type W	-0.14	0.22	-0.61	.54	0.87

Note. SE = standard error; OR = odds ratio.

between TD and CD pairs was consistent regardless of which option served as the target.

Estimated marginal means (logit scale) for each condition were as follows: CD, N: 1.34 (SE = 0.13); TD, N: 2.49 (SE = 0.16); CD, W: 1.33 (SE = 0.13); TD, W: 2.34 (SE = 0.16). Pairwise contrasts confirmed that the TD–CD accuracy difference was highly significant for both target types ($p < .0001$), while the difference between W and N as targets was negligible.

These results provide strong evidence that the dominance asymmetry observed in Experiment 1 was not driven by a baseline preference for either core option. The effect of pair type on accuracy was robust and consistent across both target types. Thus, the absence of bias correction in Experiment 1 does not compromise the validity or interpretability of the main findings.

Declarations

Funding

No funds, grants, or other support were received for conducting this study.

Conflicts of interest/Competing interests

The authors have no competing interests to declare that are relevant to the content of this article.

Ethics approval

All experiments were approved by the Institute Ethics Committee.

Consent to participate

Participants provided informed consent before participation and received compensation for their time.

Consent for publication

Not applicable.

Availability of data and materials

Stimulus files, raw data for Experiment 1, Experiment 2, and Experiment 3 are made available online at OSF. Experiment 1 was preregistered, and the preregistration is available at OSF.

Code availability

The analysis code for this study is available at OSF.

Author Contributions

Conceptualization: TR; NiS, Investigation: TR. Methodology: TR; NiS; NaS. Data curation: TR; NiS, Data visualisation: TR; NiS; NaS. Writing — original draft: TR. Writing — review & editing: TR, NaS; NiS. Supervision, Validation: NiS; NaS. All authors approved the final submitted draft.

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