’Sounds like a skill issue’: what makes you quit at chess?

Hariharan Purohit* (hariharan22@iitk.ac.in)

Department of Cognitive Science, IIT Kanpur, India

Nisheeth Srivastava (nsrivast@iitk.ac.in)

Department of Cognitive Science, IIT Kanpur, India

Introduction

What determines the transition towards stopping an activity? This has been studied as a class of problems called ’optimal stopping problems’ (OSPs) where the goal is to decide when to stop collecting information in order to obtain the best possible outcome for a sequence of presented options. The problems come with the constraint that one cannot return to foregone options. Mathematically, the solution follows an optimal strategy where an option is chosen based on its relative/absolute value surpassing a threshold. Threshold parameters derived from optimal stopping models lack psychological relevance and are uninformative about the process underlying this threshold formation (Bugbee & Gonzalez, 2022).

From a metacognitive perspective, deciding to stop can be framed as deciding an optimal computation for selecting a stopping strategy. This ’meta-reasoning’ on where to place the stopping threshold has been shown to depend on past experience and resource availability (Lieder & Griffiths, 2017; Jagga et al., 2021). Both OSPs and meta-reasoning approaches are based on carefully curated laboratory tasks. They capiltalize on accurate predictive models while compromising on ecological validity.

Stopping decisions are also intimately involved in quitting decisions. Quitting is defined as completely stopping an activity that a person would like to continue. In order to investigate quitting behaviors, we wanted to step beyond laboratory constraints.

Online chess serves as a naturalistic context where cognitive processes can be studied within rule-based, constrained environments. Player skills are defined via ELO rating system accomodating game factors such as wins/losses, and change in ratings over time. Furthermore, quitting a chess match possesses actual consequences for a player by affecting their rankings/ratings. We used chess as a testbed for understanding quitting due to its adversarial nature and availability of large amounts of data that contribute towards its ecological relevance.

Methods

Data Pre-processing

We extracted 1 million classical chess games from the chess server *lichess.org*. Players were randomly sampled (N_{total}=13,000) from the dataset and matches fed into a chess evaluation engine *(Stockfish v10)*. The engine performs a move-by-move analysis for each game and assigns a numerical value for each move signifying its advantage w.r.t to the white player. Game outcome as a result of checkmate is also generated by the engine. Games classified as 'Normal' termination were considered for the analysis as they either end with checkmate or resign by a player. Games were further filtered to include only those games where min. 30 minutes are allotted to each player as move times ('time control').

Resign games are assigned at the level of the player. Games where the last move is not a checkmate and the game result indicates an opponent win are classified as resign games for the player. Therefore, we retained players (N_{resign}=600) that had at least 1 resigned game in their roster.

Data analysis

We were interested in defining a player-level psychological variable that predicts their propensity to quit chess matches. Within chess, we defined quitting as the rate at which a player resigns matches (called 'quit rate'). We assumed that move numbers represent a discrete unit within which players think about their next move and also represent the game state quality w.r.t the player.

Using survival analysis, quit rate (QR) is operationalized as the hazard rate - probability of resigning on the next move given survival until this move. In order to model QR, two types of mixed-effect hazard regression models are formulated. The first model ('conditional model') considers only resign games from each player's roster while the second model ('unconditional model') considers the complete roster for each player. In both models, fixed effects refer to various game factors that affect QR while random-effects refer to the players tagged by player ID.

Results

We selected covariates that have had relevance for predicting and assessing human chess performance such as player ELO ratings, difference in ELO ratings between player and opponent, and evaluation of last move. Having quit in the past game was measured by checking if one has quit in the past 'k' games (*range* = 1 to 10).

For the conditional model (Table 1), player ELO and ELO difference had negative and positive relations with QR, respectively. A positive interaction effect was also observed. In terms of effect sizes, player ELO ($exp(\beta)$=0.81) and ELO difference ($exp(\beta)$=1.06) predict a 19% increase and 6% reduction in QR, respectively.

For the unconditional model (Table 2), ELO difference and its interaction with player ELO are negatively related to QR. Having quit in the previous match showed a positive relation with QR. In effect sizes, ELO difference ($exp(\beta)$=0.73) and player ELO x difference ($exp(\beta)$=0.94) predict a 27% and 6% increase in QR, respectively. Meanwhile, previous match quit ($exp(\beta)$=1.02) predicted a 2% reduction in QR.

Discussion

Deciding when to quit an activity depends on both cognitive and task-specific factors. In this work, we used chess as ecological testbed to understand when humans decide to 'call it quits'. We operationalized quitting as a rate variable describing how likely they are to quit a chess game and what factors would be involved in making this decision.

Using chess players' resign games to characterize their quitting behavior we validated

Covariate	β	95% CI	p-value
Evaluation	0.01	0.00,0.02	0.2
player ELO	-0.21	-0.23,-0.18	<0.001
ELO Difference	0.06	0.04,0.08	<0.001
player ELO x Difference	0.02	0.01,0.04	<0.001

Table 1: Conditional model with only resign games for each player. CI = Confidence Interval.

Covariate	β	95% CI	p-value
Evaluation	-0.01	-0.02,0.00	0.051
player ELO	-0.09	-0.12,-0.06	<0.001
ELO Difference	-0.32	-0.34,-0.30	<0.001
Past Quit (k_1)	0.02	0.01,0.04	0.003
player ELO x Difference	-0.06	-0.08,-0.04	<0.001

Table 2: Unconditional model with all games for each player. CI = Confidence Interval.

an intuitive concept in chess; a player is more likely to quit when they are at a skill disadvantage compared to the opponent. However, when the full roster (wins/losses/resigns) is considered, players seem less likely to quit when faced by a tougher opponent. One interpretation would be that players select for a persistence strategy that allows them to learn newer skills from a highly skilled opponent, even when it is considered highly risky (Holdaway & Vul, 2021). Possibly, players act as rational metacognitive observers optimizing when to resign (Callaway et al., 2018).

A player's chances of resigning also seem to be affected by having quit even once in the past match. Having lost in the previous match leads to increased probability of resigning. This informs us that people's prior quitting experience impacts their current decision.

Our analysis has relevance for both chess players and researchers interested in studying quitting. Unlike previous models of stopping decisions, our analysis of quitting in an ecological context provides a simpler take on using readily available large-scale datasets to quantify an indelible aspect of human decision making.

References

Bugbee, E., & Gonzalez, C. (2022). Deciding when to stop: Cognitive models of sequential decisions in optimal stopping tasks. *In preparation*.

Callaway, F., Lieder, F., Das, P., Gul, S., Krueger, P. M., & Griffiths, T. (2018). A resource-rational analysis of human planning. In *Cogsci.*

Holdaway, C., & Vul, E. (2021). Risk-taking in adversarial games: What can 1 billion online chess games tell us? In *Proceedings of the annual meeting of the cognitive science society* (Vol. 43).

Jagga, S., Srinivasan, N., & Srivastava, N. (2021). Modeling procrastination as rational metareasoning about task effort. In *Proceedings of the annual meeting of the cognitive science society* (Vol. 43).

Lieder, F., & Griffiths, T. L. (2017). Strategy selection as rational metareasoning. *Psychological review*, *124*(6), 762.