Relationships Between Board Game Play and Pattern Recognition Ability

Matthew Melissa Makak[1] and Nicholas Sibrava[#]

[1]CUNY Baruch College, USA
[#]Advisor

ABSTRACT

Research has shown that board games and puzzles in the classroom can increase learning in children, and aid in the education of those with cognitive challenges and Autism (Laski & Siegler, 2013; Satsangi & Bofferding, 2017). However, little is known about board games' impact on the general population of adults, or what skills may be associated with frequency and complexity of play. The current study explored the relationship between board game play and pattern recognition. We hypothesized that frequency of play and complexity of certain board games would be a significant predictor of Matrix Reasoning scores, controlling for age, education, gender, and race. Results showed that frequency of Eurogame play and Thematic game play were significant predictors of pattern recognition scores. Our results suggest a possible promising link between playing certain types of board games and greater pattern recognition skills. Implications and limitations of the current results are discussed.

Introduction

Board games have long been thought of as toys for children or simply forms of entertainment that largely centered around luck and minimal strategy to win the game, such as "Candy Land" (Abbott, 1949) or "Sorry!" (Haskell & Storey, 1929). However, beyond these well-known mainstream board games, there is a large and diverse world of board games, many of which are gaining popularity as new games are being produced and targeted towards millennial consumers (Graham, 2016). The type of games gaining in popularity are those that steer away from luck driven mechanics and move towards strategy, such as Catan (Graham, 2016; "Catan", 2015), which has sold over 32 million copies since 1995, a figure that has further accelerated during the COVID-19 pandemic (Schmitz, 2020). In addition to growing sales numbers, the increasing popularity of these more complex board games is further underscored by the growth in online communities that have emerged around a shared interest in these types of games. One popular online board game platform, BoardGameGeek, counts over 2 million registered users as of 2019, increasing from 782,271 in 2013 ("2013 Board Game Geek Analytics", 2013; "2,000,000 Users", 2019).

Catan (previously branded as Settlers of Catan) is an example of an introductory or "light-weight" Eurogame, which are games specifically designed to not include luck-based mechanics (Thurm, 2021). It is important to note that board games are not only designed for children, nor for only luck-based fun. There has been an emergence of designing and developing strategy-based board games for adults. The relevance for hobby board games, specifically Eurogames, came into fruition in the 1960s in Germany where the focus was on creating adult strategy board games (Babinsack, 2007). Eurogames are a genre of board games that usually involves indirect conflict between players typically competing for resources and/or points to achieve victory; there is very little to no luck or randomness within the games, dice are a rare commodity for these type of games, they typically have a theme but usually it has very little tie to the gameplay itself, and players are never eliminated throughout the course of the game ("Eurogame", 2021). As board games have evolved away from luck-based mechanics and the popularity of more complex and cognitively demanding games (e.g., Eurogames) has increased, very little research has explored the possible relationship that such games may have with key dimensions of executive functioning, or what value such games may

have in an educational context, such as pattern recognition. The importance of recognizing patterns lies within the cognitive ability to learn mathematics and reading as well as developing cognitive flexibility and working memory (Bock et al., 2018).

Previous studies have examined the effects that playing board games can have on children's learning. Laski and Siegler (2013) conducted a study that suggested utilizing board games and puzzles in the classroom can increase learning in children. This study specifically utilized a number board game designed for the study to test kindergarteners' numerical skills using two experiments: one game using 1-10 and the other using 1-100 number range. Playing these games seemed to help the children begin to understand the numerical magnitudes and the linearity of numbers (Laski & Siegler, 2013). Numerical board games have also been shown to assist with autism spectrum disorder to learn the numerical relationship of numbers on the number line (Satsangi & Bofferding, 2017). This study, conducted with a small sample (N = 10) of children with autism spectrum disorder, showed significant improvement in their numerical knowledge after 1.5 hours of playing a number board game designed for the study (Satsangi & Bofferding, 2017). Adults with physical disabilities have also been shown to respond well to treatment facilitated by the use of board games (Neistadt, McAuley, Zecha, &Shannon, 1992), and occupational therapists often use board games to help their adult clients with physical disabilities to improve their cognitive skills as well as perceptual, sensory, and fine motor skills (Neistadt, et al., 1992).

Limited studies have been done on the effects of playing board games and learning or pattern recognition. The two studies mentioned above (Laski & Siegler, 2013; Satsangi & Bofferding, 2017) utilized board games designed specifically for the studies, but did not employ any commonly published, publicly available board games. They also focused on children but did not study the impact playing board games might have on adults' learning or pattern recognition. In contrast, one recent study by Wojtasinski and Francuz (2019) used the abstract strategy game known as “Go” to explore this relationship. Abstract strategy games such as Go are typically theme-less with simple gameplay mechanics and usually have little to no luck or randomness ("Abstract Strategy", 2019). This study reported that those who are experts in playing Go typically achieve higher scores on behavioral tests that measure visuospatial abilities as well as pattern recognition tests (Wojtasinski & Francuz, 2018). Utilizing Raven's Progressive Matrices and the APIS-Z Test's Visuospatial Abilities subscale, the researchers were able to predict if a Go player was an expert, a low-skill player, or a novice (Wojtasinski & Francuz, 2019).

While a comprehensive review of Eurogames and Thematic games is beyond the scope of this paper, we will give a brief overview of the history of these two genres of board games and their relevance for adults in the modern age.Though there has been studies on board games designed for children’s learning environments, there is a relevance in board gaming for adults as well. A study done by Steward Woods (2012), suggests that board games are not only an enjoyable hobby for adults, but create instances of balancing the social context of the gathering to play the game and the pursuit of goals within the game to achieve victory. “The emphasis on games as a social and intellectual activity, rather than an opportunity for valorization, made eurogames the perfect match for hobby gamers precisely because hobby game play has always been centrally concerned with process, rather than outcome.” (Woods, 2012) Since Eurogame players show more interest in the process of game play and the intellectual activity of such, this study aims to assess a possible correlation between one’s frequency in game play and their level of pattern recognition.

Computational thinking utilizes pattern recognition to help simplify problems, improve comprehension of complex situations, and assist in identifying solutions to a problem or goal (Berland & Lee, 2011). There have been many studies done on computational thinking and learning benefits to playing video games. Unlike video games, board games have a system of rules in which the players must manage and execute on their own whereas video games would take care of all the upkeep and maintenance of the game. An article by Berland and Lee (2011) suggests that due to the nature of maintaining rules in board games, specifically Eurogames, it is necessary for players to engage in computational thinking. In taking a further look at pattern recognition’s prevalence in gameplay, board games require the ability to understand probabilistic reasoning as well as determining risk (Hertel, 2015). These abilities are branches of pattern recognition, as one correlates information from a stimulus to information gathered

from memory (Eysenck & Keane, 2003). Board games require the players to utilize probabilistic reasoning and the understanding of risk to achieve victory in board games, which can be used by researchers to understand how people think about risk (Hertel, 2015), thus contributing to our understanding of the correlation between board games and pattern recognition.

There has been a theoretical understanding that board games have been utilized in classroom settings to help develop students' cognitive and social skills (Erdogan et al., 2022), but little has been known about the legitimacy of the correlation between board game play and its intellectual benefits. An example might be that Abstract Strategy games, such as Chess, would have a correlation with one's ability in pattern recognition. However, our study suggests that this may not be the case. Studies have shown that competitive and cooperative board games can be a helpful tool in helping to develop positive social behaviors in children (Eriksson et al., 2021) as well as soft skills in adults (Herman Bin Mohd Radzi, et al., 2020).

The purpose of the current study is to examine the relationship between gameplay frequency of Eurogames and visual pattern recognition ability. Eurogames were specifically chosen for the current study because of their rules and mechanics, which suggest the importance of pattern recognition ability to achieve success in these types of games. Eurogames require players to be the most efficient on each turn, and those who succeed in this task tend to win the game. Typically, this requires planning ahead to set up different combinations of abilities and actions a player can take on their turn, which exercises the player's ability to recognize patterns within the game.
Furthermore, there is typically an evolution within Eurogames as they play out where new actions are unlocked and players gain new abilities, thus requiring a more complex demand to recognize more sophisticated patterns in Eurogames if players are to win. The current study sought to explore the relationship between pattern recognition ability and the frequency and complexity of board game play across a number of popular board game genres in order to evaluate the possibility of Eurogame play as a unique predictor of pattern recognition.

In an online study with a merged sample of unselected undergraduates and board game enthusiasts, we explored the frequency and complexity of board game play across a number of established game genres, and asked participants to complete a Matrix Reasoning task in order to explore the relationship between board game play and pattern recognition skill, while controlling for possible confounds such as age, education, gender, and race. We hypothesized that (1) the frequency of Eurogame play would be a significant predictor of Matrix Reasoning assessment scores, when controlling for age, education, gender, race, and other genres of board games, (2) complexity rating of Eurogames played would be a significant predictor of Matrix Reasoning assessment scores, when controlling for age, education, gender, race, and other genres of board games, and (3) an interaction between both weight and frequency of Eurogames played would be a significant predictor of Matrix Reasoning assessment scores, when controlling for age, education, gender, and race.

Methods

Participants

Participants (age 18 or older) included both an undergraduate sample from a large urban college in the northeastern United States, as well as a community sample recruited from online board game enthusiast websites. Undergraduate participants were recruited via the Psychology Department SONA Participant Pool, and were compensated for their time with credit toward their course research experience requirement. Community participants were recruited via an advertisement and invitation link to the study, which was posted on game playing community websites where interested participants were directed to the anonymous Qualtrics-based survey. Recruitment for the study took place on the following game playing community websites: BoardGameGeek.com, Reddit.com (r/boardgames, r/boardgamecirclejerk, r/dice, r/Dungeons_and_Dragons, r/DnD), and Discord.com (The Brothers Murph Discord Channel). Community participants were not compensated for their time. No personally identifying information was collected, and

feedback about their performance on the pattern recognition task was not provided.

The only inclusion/exclusion criteria for the study was being age 18 or older. Data was excluded from participants who did not complete the entire study (n = 78) and those whose Qualtrics-measured time to complete the study was more than 2 Standard Deviations above or below the sample mean (n = 18).

Measures

Demographics. A demographic questionnaire was administered to assess participants' gender, age, race/ethnicity, level of education, career (or major they are currently pursuing if they were students), and their grade point average (GPA) if applicable.

Board Game Play Frequency. Participants were asked to report the frequency of their board game-playing behavior, both how often they play board games in general and how often they play specific genres of board games (a description of each genre was provided to participants; see genre descriptions below). The participants were then given a list 20 popular Eurogames with a weight (i.e., complexity) of 2.5-5.0 (medium to heavy weight; see board game complexity ratings below) according to Board Game Geek's ratings. This list of board games was adopted from the category labeled "Strategy Games" on Board Game Geek and fit the description of Eurogames provided by the Board Game Geek platform. Participants were asked for each game how often they play on a 5-point scale comprising of: "daily", "once a week", "once a month", "less than once a month", or "never". Those who answered "never" to every game on the list were given the option to enter up to three non-listed board games that they play most frequently, which were then coded for genre.

Board Game Genre. Board game developers, manufacturers, and enthusiasts categorize different board games into several possible categories (or genres) based on a number of variables, including similarities in theme, game play mechanics, intensity of rules, degree of luck or chance involved in gameplay, and game difficulty, among other factors ("Game Genres", 2019). Two major families of board games are generally recognized, Mainstream Games and Hobby Games. Mainstream Games are mass-market games that typically have simple rules and many times have luck involved in the gameplay mechanics, and generally focus on ease of play. Mainstream Games may or may not have a theme, but the gameplay mechanisms do not usually tie to its theme. Hobby Games are primarily sold via specialty outlets, are targeted to board game enthusiasts, and tend to be more rules intensive and more difficult than Mainstream Games. Generally recognized genres of Hobby Games include Abstract Strategy Games, Thematic Games, Wargames, and Eurogames. Abstract Strategy games tend to have simple rules and no luck involved with a depth of strategy. They are generally theme-less or their gameplay mechanisms do not tie to its theme. Thematic Games (also known as Ameritrash games) tend to have gameplay mechanisms tied to its theme.

Luck may be involved in these games and many times require players to adapt to the unforeseen. Wargames typically attempt to replicate wars and/or battles that took place in history. Luck may be involved in these games and they usually have different units for their armies that have differing abilities and/or stats that determine what each unit can do. Eurogames typically have gameplay mechanisms that are not tied to its theme and have little to no luck involved. Usually, they have a complex ruleset and a depth of strategy is required for success in the game.

Board Game Complexity/'Weight' Ratings. Ratings from the online board game platform Board Game Geek were utilized to determine the complexity level of the board games played by participants. Board Game Geek is an online forum for those who are board game enthusiasts where they can blog about their gaming experiences, create lists of their favorite board games, rate games based on how much they enjoy them, and vote on how complex they believe a game is. As of 2019, the site had over 2 million total registered accounts of board game enthusiasts, with each registered user having the ability to rate how complex any board game is ("Ratings", 2021). The complexity levels of the board games are rated on a 5-point weight scale labeled Light, Medium Light, Medium, Medium Heavy, and Heavy. A rating of 1 is considered to be a light-weight (low complexity) game while a rating of 5 is considered to be a heavy-weight (high-complexity) game. For the purposes of this study, board games under the "Strategy" category on Board Game Geek and that fit the characteristics of a Eurogame were the primary focus, given the skills required for success in Eurogame play.

Pattern Recognition. To measure the participants' level of pattern recognition ability, a Matrix Reasoning

assessment tool designed to assess one's ability to recognize increasingly complex visual patterns was employed in the current study. The specific Matrix Reasoning test used in the current study was taken from the International Cognitive Ability Resource Project (Condon & Revelle, 2014), and presents participants with 11 items of varying difficulty. Each item presents participants with a 3x3 matrix that shows an evolving visual pattern in 8 of the squares, with the 9th left blank. Participants are then asked to choose (from 6 options) which image should come next, given the pattern that unfolded in the previous 8 squares. The Matrix Reasoning assessment is part of the International Cognitive Ability Resource Project, a public domain assessment battery developed to measure a range of cognitive abilities. When tested for reliability in the standardization sample, the Matrix Reasoning test showed adequate internal consistency (α =.68), and in the current study demonstrated adequate to good internal consistency reliability (α =.77). When tested for validity in the standardization sample as part of the full assessment battery, the results suggested a "strong group discriminant validity" (Condon & Revelle, 2014). Scores on this assessment are derived by summing the total number of correct responses, and these data were analyzed in concert with participant game playing behavior in order to test our hypotheses.

Procedure

Upon accepting the invitation to participate in the study and clicking on the invitation link, participants were taken to the Qualtrics-based study and provided with additional information about the study and informed consent was obtained. Then, participants were given a brief set of questions to complete (demographic and game playing experience), and were then presented with the pattern recognition assessment. Participants were not time limited, and participants took 11 minutes on average to complete the study. Once participants completed the pattern recognition assessment, they were presented with additional study information and thanked for their time, and individuals from the undergraduate sample were compensated for their participation.

Results

Descriptives and Preliminary Analyses. A total of 374 participants were recruited from the undergraduate participant pool (n = 237) and online board gaming community forums (n=137). Demographic characteristics of the sample are presented in Table 1.

Table 1. Demographic characteristics of the sample

Age	Participants (N)	Participants (%)
18-24	226	60.4
25-34	70	18.7
35-44	40	10.7
45-54	20	5.3
55-64	13	3.5
65-74	5	1.3
Gender		
Male	198	52.9
Female	176	47.1
Race		
Latino	37	9.9
Black/AA	13	3.5
White	179	47.9
Asian	115	30.7

Other	30	8.0
Education		
Less Than High School	2	0.5
High School	104	27.8
Some College	84	22.5
College or Higher	184	49.2

Frequencies of board game play by genre are presented in Table 2.

Table 2. Frequency of board game play by genre.

Reported Frequency of Board Game Play (% of Sample)				
Never	Less Than Once Per Month	Once per Month	Once Per Week	Daily

	Any Game	21.9	32.6	10.7	24.1	10.7
	Mainstream	31.6	50.3	11.5	5.1	1.3
	Abstract	34.2	40.4	16.3	8.3	0.8
Strategy						
	Thematic	44.7	21.4	12.6	17.9	3.5
	Wargames	58.6	27.8	7.5	4.0	1.6
	Eurogames	50.8	14.2	10.2	19.0	5.6

Demographic group comparisons revealed a number of significant differences in gameplay frequency based on race, education level, gender, and age. With regard to race, White participants reported significantly higher gameplay frequency than all other racial/ethnic groups for Any Board Games ($F(4, 373) = 25.17$, $p < .001$), Abstract Strategy Games ($F(4, 373) = 3.69$, $p < .006$), Thematic Games ($F(4, 373) = 15.19$, $p < .001$), and Eurogames ($F(4, 372) = 22.02$, $p < .001$). With regard to education, participants with a college degree or greater reported significantly higher gameplay frequency than all other education levels for Any Board Games ($F(3, 358) = 31.82$, $p < .001$), Abstract Strategy Games ($F(3, 358) = 3.69$, $p < .012$), Thematic Games ($F(3, 358) = 26.21$, $p < .001$), and Eurogames ($F(3, 357) = 27.40$, $p < .001$). With regard to gender, Male participants reported significantly higher gameplay frequency than Female participants for Any Board Games ($F(1, 373) = 12.83$, $p < .001$), Abstract Strategy Games ($F(1, 373) = 10.06$, $p < .002$), Thematic Games ($F(1, 373) = 22.39$, $p < .001$), Wargames ($F(1, 371) = 17.85$, $p < .001$), and Eurogames ($F(1, 372) = 27.67$, $p < .001$). Finally, gameplay frequency was significantly, positively correlated with age for all genres of game ($rs = 0.14$ to 0.57, all $ps < .009$), except for Mainstream board games ($r = -0.01$, $p = .917$).

Demographic group comparisons also revealed significant differences in Matrix Reasoning scores by race, education, gender, and age. With regard to race, White participants reported significantly higher Matrix Reasoning scores than all other racial/ethnic groups ($F(4, 372 = 8.94$, $p < .001$). With regard to education, participants with a college degree or greater reported significantly higher Matrix Reasoning scores than all other education levels ($F(3, 354 = 14.11$, $p < .001$). With regard to gender, Male participants reported significantly higher Matrix Reasoning scores Female participants ($F(1, 372 = 22.64$, $p < .001$). Finally, Matrix Reasoning scores were significantly, positively correlated with age ($r = 0.36$, $p < .001$).

Hypothesis Tests. To test our hypothesis that frequency of Eurogame-play would be a significant predictor of scores on the Matrix Reasoning assessment, a step-wise multiple regression analysis was conducted with race, education, gender, and age entered in Step 1 as covariates, and all other genres of board game play frequency entered in Step 2. The regression analysis found that the Step 1 covariates explained 19.0% of the variance in Matrix Reasoning scores ($R2 = .190$, $F(4, 353) = 20.48$, $p < .001$), while frequency of all other genres of board game play explained an additional 7.3% of the variance in Matrix Reasoning scores ($R2\Delta = .073$, $F(9, 353) = 13.62$, $p < .001$). The individual genres of game play frequency were examined further and indicated that frequency of Eurogame play ($\beta = 0.24$, $t = 3.12$, $p < .002$) and Thematic game play ($\beta = 0.17$, $t = 2.09$, $p < .03$) were the only genres of game play that emerged as significant predictors of Matrix Reasoning scores.

To test our second hypothesis that complexity (weight) of Eurogame-play would be a significant predictor of scores on the Matrix Reasoning assessment, a step-wise multiple regression analysis was conducted with race, education, gender, and age entered in Step 1 as covariates, and complexity (weight) ratings of all Eurogames played were entered in Step 2. This analysis found that complexity (weight) of Eurogames played was not a significant predictor of Matrix Reasoning assessment scores ($R2\Delta = .000$, $F\Delta (1, 351) = 0.05$, $p = .828$).

To test our final hypothesis that the interaction of frequency and complexity (weight) of Eurogame-play would be a significant predictor of scores on the Matrix Reasoning assessment, a step-wise multiple regression analysis was conducted with race, education, gender, and age entered in Step 1 as covariates, and the frequency x complexity (weight) interaction term for all Eurogames played was entered in Step 2. This analysis found that the

interaction of frequency x complexity of Eurogames played was not a significant predictor of Matrix Reasoning assessment scores ($R2\Delta = .002$, $F\Delta (1, 344) = 1.02$, $p = .313$)..

Discussion

The aim of the current study was to explore the relationship between board game play and pattern recognition ability, with a specific focus on one particular genre of board game, Eurogames, which are characterized by game design and game play mechanics that require pattern recognition ability in order to achieve success. Specifically, we predicted that the frequency of Eurogame play would significantly predict scores on a measure of pattern recognition, Matrix Reasoning, even when controlling for other game types as well as other key variables associated with pattern recognition ability, including race, education, gender, and age. Furthermore, in addition to frequency of Eurogame play, we also explored the relationship between pattern recognition and game complexity, as well as the interaction of game play frequency and complexity as a predictor of pattern recognition.

The results supported our first hypothesis, demonstrating that the frequency of Eurogame play was a significant predictor of pattern recognition ability in the current study. Our analysis also revealed that frequency of Thematic game play was also a significant predictor of pattern recognition, contrary to our expectations. Our findings demonstrate that the frequency of playing Eurogames and/or Thematic board games was associated with higher pattern recognition ability, even when accounting for the effects of race, education, gender, age, and all other genres of board game play.

Thematic gameplay frequency predicting pattern recognition was somewhat surprising, given the differences in how Thematic gameplay functions compared to Eurogames. However, Thematic Games have a commonality with Eurogames in that they both require players to be efficient with their turns to ultimately win the game. Problem solving is a significant component of Thematic Games as there is usually new information being revealed to the player as the game proceeds, requiring players to adapt to changing circumstances, deal with unforeseen circumstances, and recognize new patterns in order to succeed as the game advances. Thus, this need to adapt to the unpredictable nature of this genre of game may indeed require a strong ability to recognize patterns in order to determine the best possible solution to novel challenges.

Given the results of the current study, there may be value in exploring the potential benefits of playing Eurogames and Thematic games on a frequent basis. It is possible that incorporating the use of these genres of games in an educational setting can have a positive impact on students' ability to recognize patterns, which consequently could improve problem solving skills, the ability to make connections and recognize trends, and develop innovative ideas due to analysis of patterns. It may be possible to utilize Eurogames and Thematic games in a higher education setting also, as a fun, interesting way of teaching and engaging college students. For example, classes could use the board game mentioned earlier, Catan, to showcase planning ahead and utilizing resources at your disposal efficiently to ensure productivity. Catan's core mechanics revolve around generating resources, trading resources, and building structures by spending these resources to gain victory points ("Catan", 2015).
Students may need to think outside the box to accomplish obtaining valuable resources and noticing which structures would be most beneficial to them each turn to ultimately win the game. Continuing with our example of Catan, these games can also be used in companies for employees where it is necessary for their success to recognize trends and patterns and/or solve problems.

It is important to note that the data did not support our second hypothesis regarding the weight of Eurogames predicting pattern recognition ability, suggesting that the design and game play mechanics of Eurogames may be more relevant to understanding their relationship to pattern recognition than the complexity of any given Eurogame. Furthermore, the data did not find that the interaction of frequency and weight of Eurogame play was a significant predictor of pattern recognition ability, and thus our third hypothesis was not supported. The failure to find a significant result when including weight in our analyses may indicate, if playing Eurogames can be shown to improve pattern recognition ability, that such a relationship might be found regardless of complexity and therefore would

lower barriers for a broader dissemination of such games into earlier educational settings and among novice game players.

Additional research is needed to determine a possible causal relationship between gameplay and pattern recognition skill. Indeed, the correlational nature of the current study cannot preclude the possibility that individuals with strong pattern recognition ability are simply more drawn to Eurogames and Thematic games. However, if future research can establish such a link between playing these games and enhanced pattern recognition, it may be possible that incorporating or adapting Eurogames and Thematic games for classroom settings could have a positive impact on developing one's ability for pattern recognition, which is a critical skill for problem solving in many academic and occupational domains (Hertel, 2015). Such research would build on prior applied game playing research that has employed games with children with developmental disabilities (e.g., Laski & Siegler, 2013) and the use of games in occupational therapy settings (e.g., Neistadt, et al., 1992). Our study focused on participants 18 years or older, with the majority of our sample of college age, thus higher education settings may also be an ideal initial focal point for attempts to incorporate Eurogames and Thematic games into the classroom. As these games continue to grow in popularity, future research exploring their potential cognitive benefits in educational settings is warranted.

Limitations

In addition to the important question of causality noted above, the current study had additional important limitations. The study was given to college students who were required to participate in a certain number of studies to complete the class, so this could have affected participant motivation for the study for a large portion of the sample. Additionally, the board game enthusiast sample was not compensated for their participation, thus possibly having an effect on their motivation when completing the survey.

Participants were not provided with options to rate the frequency with which they played the board games they wrote for the free response option, which may have given us further insight on frequency of playing board games in concert with complexity rating and its impact on pattern recognition. Furthermore, though descriptions were provided for each genre of board games on the questionnaire, it is still possible for participants to have interpreted the description and categorized board games differently based on opinion, which may have had an impact on the way they answered the gaming experience questions. It is important to note that categorizing any given game's genre can also be open for interpretation, and not every game neatly fits into one category, therefore board games that were identified as such on our list may not necessarily be considered a Eurogame to everyone who plays board games, and games that were omitted from the list may be considered Eurogames by others. Relatedly, evaluating and coding each free-response board game written-in by the participants may lead to possible misclassification, as the judgment of weight and genre of the game is open to some degree of interpretation, even though we relied on consensus ratings on BoardGameGeek. Since BoardGameGeek is the leading forum on board game information, most of the information gathered on board game definitions and complexity scale was taken from just this one site, limiting the amount of sources for board game play information utilized in this study. It should also be noted that only one researcher labeled each of the board games' genres while it would have been best to have multiple raters label the genres of each of the board games to limit biases of interpretations.

With regard to our use of a Matrix Reasoning assessment to measure pattern recognition, it is important to note that pattern recognition is a complex neurocognitive ability, and the full scope of which cannot be adequately captured by Matrix Reasoning alone. Thus, future research should include multiple measures of pattern recognition ability in order to more fully assess this construct. Finally, although our sample was moderately sized and consisted of both a student and gaming community sample, a larger and more diverse sample would have improved the generalizability of our findings.

A future study could have participants who do not play board games regularly and have not been exposed to games outside of the light-weight range complete the Matrix Reasoning assessment. Then, the same participants would be taught and play Eurogames (for a predetermined length of time) and then take the assessment again after

the specified time and observe for any changes in scores. This current study can serve as a stepping stone to this future research, thus discovering whether or not frequency of playing Eurogames is a cause of an increase in an individual's level of pattern recognition.

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