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EYE-TRACKING ANALYSIS OF VISUAL DESIGN PREFERENCES IN BOARD GAME SELECTION: INTEGRATING COGNITIVE ATTENTION AND MEMORY RETENTION FOR EFFECTIVE LUDIC INTERFACE DESIGN

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Abstract

This empirical study examines the relationship between visual design preferences and cognitive retention in board game evaluations using eye-tracking technology combined with structured recall interviews. Sixty participants (N = 60) viewed four distinct illustration styles (cartoonish, modern, doodle drawing, and animated/3D) while gaze data were recorded using the Tobii VT3 Mini and iMotions software, followed by a cognitive recall assessment 10 minutes post-exposure. Participants subsequently evaluated four board game designs differing in illustration style, color saturation, and visual complexity. Results show that cartoonish illustrations were the most liked style (30%) and that Animated/3D styles achieved perfect recall (100%), while Modern and Doodle Drawing styles also demonstrated high engagement and memory performance. High-saturation warm-color designs were consistently preferred and more memorable than low-saturation alternatives, with simplified, visually clear designs (Design 4) recalled with the highest accuracy. Qualitative feedback highlighted simplicity, clarity, and color vibrancy as primary drivers of preference. These findings provide empirical evidence for how visual design elements influence attention and memory in simulation board interfaces and offer actionable recommendations for optimizing visual aesthetics to enhance user engagement and cognitive retention. The study contributes to the emerging field of neuro-ludic design, with implications for both analog and digital game design practices.

Keywords: *Eye-tracking, simulation board design, visual preferences, cognitive retention, design aesthetics, user experience, memory recall, illustration styles.*

1. Introduction

Board designs rely fundamentally on static visual design to capture attention, communicate simulation mechanics, and create memorable player experiences (Zagal & Deterding, 2018). In recent years, a spike has been observed in the global playing cards and board games market, which was valued at USD 19.90 billion in 2024 and is projected to reach USD 31.93 billion by 2030, growing at a CAGR of 8.3% from 2025 to 2030 (Playing Cards & Board Games Market, n.d.). These statistics have increased the competition among game designers, which leads to the necessity of better visual design for market differentiation and player engagement.

Despite this commercial importance, systematic empirical research based on how visual design elements influence player preferences and cognitive engagement remains limited (Mai et al., 2025). Most board game design decisions have mainly relied on designer intuition, focus group feedback, and playtesting rather than quantitative measures of cognitive engagement and attention allocation (Kosa & Yilmaz, 2017). This methodological gap represents a significant opportunity for applying advanced neurocognitive research technologies to generate evidence-based design recommendations.

Eye-tracking technology has emerged over the past two decades as a powerful non-invasive methodology for measuring visual attention in real-time, providing quantitative data about where individuals direct their gaze, for how long, and in what sequence (Just & Carpenter, 1976). Early applications of eye-tracking focused primarily on reading comprehension and visual search tasks (Rayner, 1998). However, current applications have expanded to encompass human-computer interaction, user experience research, consumer behavior analysis, and increasingly, game design evaluation (Tobii, n.d.).

The integration of eye-tracking with cognitive psychology methodologies helps the authors to find out the empirical results of perfect board game design that players would like.

2. Theoretical framework & research questions

This study draws on three main theoretical frameworks: (1) visual attention theory, (2) cognitive load theory, and (3) aesthetic psychology.

Visual Attention Theory explains that human attention is a limited cognitive resource that is allocated preferentially to stimuli containing certain characteristics: novelty, salience, movement, color contrast, and personal relevance (Posner & Petersen, 1990). In the context of static visual design, elements with high color saturation, complex patterns, and clear spatial contrast capture attention more effectively than minimalist designs (Palmer, 1999).

Cognitive Load Theory, developed by Sweller (1988), shows that learning and information processing capacity are limited, with three types of cognitive load: intrinsic (inherent difficulty of material), extraneous (imposed by design), and germane (effort directed toward processing goals). When it is applied to the design of a business simulation board, it can be assumed that visual complexity imposes extra cognitive load. Simplified, well-organized visual designs reduce extraneous load, which would allow cognitive resources to focus on gameplay mechanics and strategic decision-making.

Aesthetic Psychology examines how individuals respond emotionally and cognitively to visual design elements, with established research demonstrating that perceived beauty influences initial product selection, sustained engagement, and brand loyalty (Kahn, 2004). Colors, illustration styles, and visual composition all contribute to aesthetic perception and emotional response.

This study addresses the following primary research questions:

1. Which illustration styles (cartoonish, modern, doodle, animated/ 3D) elicit the highest visual attention (measured via fixation duration and gaze density) and preferential selection in board game design?
2. What is the relationship between initial visual preference (measured via eye-tracking metrics) and subsequent memory retention (measured via structured recall interviews conducted 10 minutes post-stimulus)?
3. What qualitative factors (expressed in participant interviews) drive board game design selection, and do these factors align with quantitative eye-tracking and memory metrics?

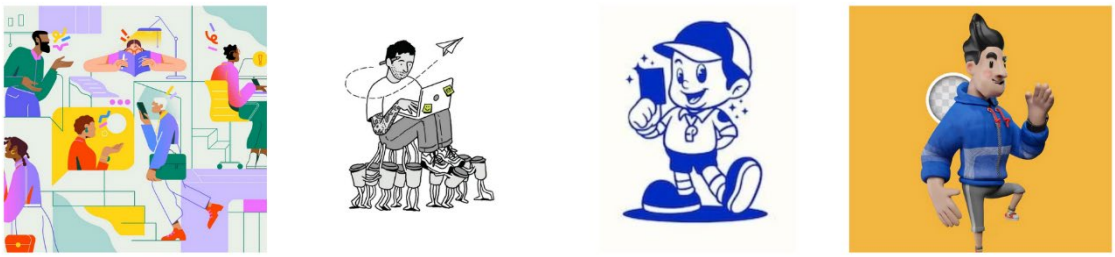
This research provides game designers, UX professionals, and product developers with evidence-based frameworks for optimizing visual design elements in board games and related products that need users' evaluation and sustained engagement.

3. Research design

This study employed a mixed-methods design integrating quantitative eye-tracking metrics with qualitative interview data. The research includes the following phases:

Phase 1 (Illustration Style Evaluation): Participants viewed four illustration styles with several human figures (cartoonish, modern, doodle-drawing, and animated/3D representations) while eye-tracking captured gaze patterns from a website.

Figure 1. Figure selections.



Phase 2 (Board Game Design Evaluation): Participants were subsequently presented with four distinct board game designs varying in illustration style, color saturation, and visual complexity. Using the same eye-tracking process, gaze patterns were recorded. Participants then selected their preferred design from the four options.

Figure 2. Board game selections.

Phase 3 (Cognitive Recall Interview): Approximately 10 minutes after initial stimulus presentation, participants engaged in structured interviews assessing color recall, design element recognition, and subjective preference. Interviews were conducted verbally with responses recorded in standardized response forms.

4. Analysis

All 60 participants completed the full experimental protocol. No participants were excluded due to tracking failures, calibration difficulties, or incomplete data. Across the four illustration styles, preference distribution was:

Table 1. Preference distribution according to illustration styles.

Illustration Style	Selection Frequency	Recall Accuracy (Gaze vs. Interview)	Color Recall Accuracy (Gaze vs. Interview)
Cartoonish	18	94.44%	77.78%
Modern	17	88.3%	100%
Doodle Drawing	10	80.0%	100%
Animated/3D	15	100%	100%

Cartoonish illustrations were selected by most of the participants (30%); on the other hand, 100% participants were able to recall the Animated/3D character. While designs incorporating high color saturation (Design 1, 2 and 4) were preferred by more than 25% each, participants preferred low-saturation designs (Design 3) significantly less by only 16%. Another noticeable factor in board game design that the authors noticed: warm-color board game designs (Design 3 and 4) were preferred by 40.68% of participants (23.73% and 16.95%)**,** significantly exceeding retro and vibrant color-based designs (Design 1 and 2), which were preferred by 59.32% (33.90% and 25.42%). During the interview, participants accurately recalled the designs when presented with board game designs that were significantly higher overall from the previous sets of designs (for Designs 1 to 4, respectively 90%, 60%, 70%, 100%). Apparently, all participants could remember the exact selection of a clean, simplified board game (Design 4).

5. Discussion and recommendations

This study shows that eye-tracking technology, combined with cognitive recall assessment and qualitative analysis, effectively identifies visual design characteristics that can showcase high engagement and memorable impressions. Four key findings emerged from the experiment. First, Cartoonish illustration styles were the most frequently selected, with 30% of participants choosing them. This indicates that simplified, approachable visual language resonates strongly with users. Second, visual engagement predicted memory retention, as participants accurately recalled Animated/3D characters at 100%, and recall for Cartoonish, Modern, and Doodle Drawing illustrations ranged from 80% to 94.44%, highlighting that designs capturing attention promote stronger memory consolidation. Third, in board game designs, color saturation and warmth influenced preferences, with high-saturation designs (Designs 1, 2, and 4) preferred by over 25% of participants and warm-color designs (Designs 3 and 4) favored by 40.68%, while cooler or more complex designs (Designs 1 and 2) accounted for 59.32%. Finally, qualitative analysis revealed that participants consistently valued simplicity, clarity, and vibrant colors, with the clean and simplified Design

4 being perfectly recalled by all participants, reinforcing the importance of clear, visually engaging, and easily interpretable design in supporting both preference and memory retention.

Based on the study findings, several design recommendations emerge for board game creators. First, prioritize simplified visual hierarchies by making critical gameplay elements prominent and minimizing cognitive load through high saturation, size, or contrast for supporting elements. Second, employ high-saturation warm colors (red, yellow, orange) for primary game components to enhance attention, engagement, and memorability, reserving cooler colors for backgrounds or secondary elements. Third, match visual style to the target audience, recognizing that while cartoonish designs appeal to general audiences, modern or complex styles may suit specialized players. Finally, validate designs through eye-tracking prototyping, using fixation patterns and gaze distribution as objective metrics to optimize engagement and recall before final production.

6. Conclusion

This study indicates that integrating eye-tracking with cognitive recall assessments and qualitative analysis provides a robust framework for evaluating board game visual design. Cartoonish and Animated/3D illustration styles captured the greatest attention and were most accurately recalled, highlighting the impact of simplified, approachable visuals on engagement and memory retention. Color saturation and warmth further influenced preference, with high-saturation warm colors enhancing both appeal and memorability. Qualitative insights reinforced the importance of clarity, simplicity, and vibrant color in guiding design selection. These findings offer actionable guidance for designers, suggesting that prioritizing clear visual hierarchies, strategically applying color, and validating designs through empirical eye-tracking methods can optimize user engagement and long-term recall, with implications extending to both analog and digital game design.

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