The Effectiveness of Visual Attention Patterns in the Process of Spatial Exploration in a 3D Video Game Environment

Bartosz Krukowski[1], Mateusz Zawisza[1], Aneta Wiśniewska[1][0000−0002−8746−0047], Adam Wojciechowski[1][0000−0003−3786−7225], and Rafał Szrajber[1][0000−0003−2777−0251]

Institute of Information Technology
Lodz University of Technology
215 Wólczańska Street
90-924 Lodz, Poland
https://it.p.lodz.pl/

Abstract. This study examines the effectiveness of visual navigation cues in guiding player movement within 3D virtual environments. Using experimental levels with lighting contrast and object geometry cues at three intensity levels, the research identifies the minimum cue strength needed to influence player navigation effectively. Differences in cue responsiveness between casual and advanced players were also analyzed. The findings reveal threshold values for subtle yet effective navigation methods, providing practical insights for level designers. These results can enhance the development of user-friendly and engaging game environments, catering to players of varying skill levels.

Keywords: wayfinding · video game · environment · visual cues

1 Introduction

In contemporary society, video games have become a highly popular form of entertainment, catering to players of all ages and skill levels. Game development studios strive to make their products accessible to a broad audience. In recent years, major industry players have demonstrated a comprehensive approach to accessibility by integrating features designed to support individuals with disabilities, including those with visual or motor impairments. A critical component of modern games is the exploration of three-dimensional spaces. If a level designed by developers is overly simplistic, players may derive little satisfaction from discovering objectives such as exits or hidden treasures. Conversely, levels that are excessively complex or poorly designed can lead to frustration, disorientation, and disengagement. To balance these extremes, level designers have developed principles and methodologies [8, 14], often through iterative processes, to craft environments that are both engaging and navigable. This study explores methods for guiding players in virtual environments, focusing on how

ICCS Camera Ready Version 2025
To cite this paper please use the final published version:
DOI: 10.1007/978-3-031-97573-8_5

various navigational cues influence movement and decision-making. The research aims to evaluate specific types of cues integrated into game environments and determine the minimum intensity required to effectively direct player behavior without compromising immersion. The findings presented in this paper are intended to provide practical insights for level designers, aiding in the creation of virtual spaces that are both challenging and accessible, enhancing the overall player experience.

2 Related Works

As the gaming industry has advanced, designers have developed well-established methods to effectively guide players and direct them along intended paths. Over time, these methods have evolved into structured design patterns, akin to those introduced by Christopher Alexander in the field of architecture [1]. These patterns systematically define specific problems, propose solutions, and outline the potential outcomes of their application. The increasing number and refinement of these patterns correlate directly with the growing body of research dedicated to their efficacy and impact on players' experiences during gameplay. Experimental studies aim to validate the effectiveness of these methods, providing empirical evidence to support their use in game design.

An important area of this research focuses on the influence of visual attention patterns on players' exploratory behavior and decision-making. A notable contribution to this field is the work of Barney [2], which adapts the concept of pattern language to address design challenges in games, encompassing both mechanical and environmental aspects. The author elaborates on how to construct custom pattern languages derived from established game productions and apply them to game development. Ongoing studies by various research teams continue to assess the effectiveness and efficiency of these patterns, contributing to a deeper understanding of their role in enhancing player engagement and navigation within virtual environments.

The use of various elements such as light, motion, color, and sound to guide players within virtual environments is comprehensively discussed in the study by Hoeg [5]. The research involved the creation of an advanced level designed to simulate a segment of a first-person shooter game. Participants navigated through a building with the objective of locating and rescuing hostages. The environment was carefully constructed to include decision points during corridor exploration, allowing the study to assess whether specific methods effectively captured players' attention, influencing their choice between two available paths. The findings identified light as one of the most impactful techniques for influencing player decision-making.

Player decision-making influenced by contrast is examined in detail by Winn [15]. The authors argue that the proper interpretation of this effect is to answer the question, "Where should the player go?" rather than "Where must the player go?" Their research highlights the effectiveness of contrast created through increased lighting or brightening of the main path. The results confirmed that

ICCS Camera Ready Version 2025
To cite this paper please use the final published version:
DOI: 10.1007/978-3-031-97573-8_5

contrast significantly influences player behavior, as also supported by Liszio [9], who categorizes contrast among the most effective yet minimally intrusive navigation methods. These techniques aim to naturally draw the player's gaze toward a specific object or path.

Winters [16] further explored the role of form contrast in guiding player navigation. Post-experiment interviews revealed that all participants identified contrast as a key factor influencing their decisions, underscoring its importance in virtual environment design.

The challenges of guiding players using lightened paths can be effectively addressed through contrast-based methods, as exemplified by techniques employed at Disneyland and described by Rogers [13]. In his lecture, Rogers demonstrates how park visitors are guided using environmental light and contrast. The park's design features a well-lit central castle, towering over its surroundings and visible from a distance. As the park prepares to close, lighting in areas farther from the castle is gradually dimmed, increasing the contrast between the central castle and its surroundings. This technique naturally draws visitors' attention to the castle, subtly encouraging them to move toward it.

The influence of contrast on decision-making during exploration was also studied by Marples [10] in the context of player navigation within a maze. Participants began at the edge of the level, with the objective of reaching a large central figure. The maze featured bifurcations offering only two paths at each decision point, where contrasting cues were employed. The results demonstrated a significant reduction in navigation time when contrasting paths were used, nearly halving the completion time compared to levels without these cues. This highlights the efficacy of contrast in directing players toward their objectives.

Lighting has been further analyzed in studies [12, 7]. Petersson [12] examined the visibility of visual cues in a 3D platform-adventure game, concluding that lighting-based cues held players' attention the longest. Knez [7] explored lighting contrast involving warm and cold colors, finding a strong player preference for warm lighting, which was chosen significantly more often, reinforcing its utility in navigation design.

Understanding how the human mind perceives space and responds to visual cues can have practical applications beyond virtual environments, including the design of public spaces. In a study by Irshad et al. [6], researchers examined the impact of navigational cues on individuals' vital parameters and mental states in high-stress situations. Participants were tasked with escaping a flooded area to reach safety. The study divided participants into three groups: one without any navigational cues, another with evacuation signs, and a third group with illuminated signs. The findings revealed that navigating without wayfinding cues significantly increased difficulty, stress, and tension. These results underscore the importance of visual attention patterns not only in aiding navigation but also in mitigating emotional strain during critical situations.

Moura et al. [11] compiled a taxonomy of recurring navigational prompts in games, categorizing them into direct methods, such as compasses or maps, and subtler approaches. Among these were markers—elements designed to draw

ICCS Camera Ready Version 2025
To cite this paper please use the final published version:
DOI: 10.1007/978-3-031-97573-8_5

attention by contrasting with the game environment. Markers could range from abstract forms, such as glowing arrows, to more integrated elements, like distinctively colored paths that blend seamlessly with the game world.

Markers associated with spatial navigation are further explored in a review by Yesiltepe et al. [17], which refers to them as landmarks. This work emphasizes two key aspects of landmarks: visibility and salience. The study found that the effectiveness of landmarks is maximized when they are placed strategically along routes and at decision points, such as intersections, reinforcing their critical role in wayfinding.

The study by Gomez et al. (2021) [3] utilized established level design patterns to investigate their influence on player curiosity. The authors identified four distinct patterns: reaching extreme points, removing visual obstructions, introducing out-of-place elements, and enhancing spatial understanding. Among these, the out-of-place element, represented by stacked stones and stones arranged in a spiral pattern across the grass, emerged as the pattern most frequently visited by players.

Compared to the existing studies, our approach introduces a more systematic assessment of cue intensity by testing each method at three levels of strength within a controlled and uniform 3D environment. Unlike prior works that often examined isolated cues or relied on real-game scenarios with multiple variables, our study isolates the effect of visual attention patterns in a neutral setting, enabling clearer attribution of player behavior to specific design elements. A key advantage of this approach is its ability to identify threshold values for cue effectiveness, offering actionable insights for level designers. On the other hand, the highly controlled nature of the environment may limit ecological validity, as real-world game levels typically feature more complex and diverse visual stimuli. Future work should aim to validate these findings in more varied and immersive game contexts.

3 Methodology

The research methodology employed in this study utilizes an open-level design to assess the impact of selected player guidance techniques. The openness of the environment is intended to facilitate unrestricted exploration by the player, thereby enabling the evaluation of the methods' effectiveness in more dynamic and unpredictable contexts.

Participants are required to progress through a series of sequential maps (stages), with each stage evaluating the efficacy of a single visual method. Each method is tested three times, with the stages arranged in a manner that exposes the player to each method initially in its weakest form, followed by its stronger and, finally, its most robust variant. Consequently, each participant navigates a total of 18 maps. In each level, the player's objective is to locate a hidden portal that will advance them to the subsequent stage. Within the narrative framing of the study, the player assumes the role of a wandering mage traversing mysterious, floating forest islands in search of magical portals. The guidance methods are

ICCS Camera Ready Version 2025
To cite this paper please use the final published version:
DOI: 10.1007/978-3-031-97573-8_5

applied in such a way as to subtly suggest the portal's location, thus influencing the player's navigation decisions.

The study begins with an introductory level, which is excluded from the analysis. This introductory phase serves to familiarize participants with the basic controls, allow them to get used to the environment, and provide an introduction to the narrative while clarifying the purpose of the game. Participants are not informed about the experimental aims or specific research focus. Instead, they are told that their objective is to locate all the portals, thereby completing all the levels presented in the study.

3.1 Environment

The design of the environment for exploration was primarily guided by two key principles: the environment had to be open to allow for free and the maps needed to be highly homogeneous—that is, stripped of any visual variety or distinctive elements (such as colors, shadows, or complex models) that could unintentionally draw the player's attention and influence decision-making. For the target environment, a forested area on an island floating in a vacuum was selected. To ensure maximal environmental simplicity, a single tree model, a few mushroom models, and a single grass texture were utilized in the construction. Additionally, the environment was intentionally stripped of color to eliminate the possible influence of color on players' decision-making. In line with this approach, the environment was also devoid of any directional light sources, relying instead on sterile ambient lighting. Consequently, the generation of shadows for all objects within the scene was disabled.

The study was designed to test all visual cues within an identical environment. For each stage of the study, the only variables that changed were the starting position of the player, the position of the portal (the target the player was tasked with reaching), and the specific visual pattern being tested, along with its designated strength. The starting positions for each level were determined such that, in the initial frame, the tested method was always visible to the player. The ideal condition for the test assumed that the player would immediately notice the relevant method and proceed towards it as soon as they began the stage. The distances between the starting and ending points for levels testing varying intensities of the same method were kept consistent.

The primary aim of the study is to replicate, as closely as possible, the conditions that gamers encounter during typical gameplay. To achieve this, the study was framed as a game that participants were asked to play through. As detailed in a previous section, the study begins with an introductory level to provide context for the game's narrative and familiarize participants with the controls. By presenting the player with a clear in-game objective, the study aims to simulate real gameplay experiences, which, as indicated by previous research [3, 12], can influence player decisions and behaviors without negatively impacting the integrity of the experiment.

ICCS Camera Ready Version 2025
To cite this paper please use the final published version:
DOI: 10.1007/978-3-031-97573-8_5

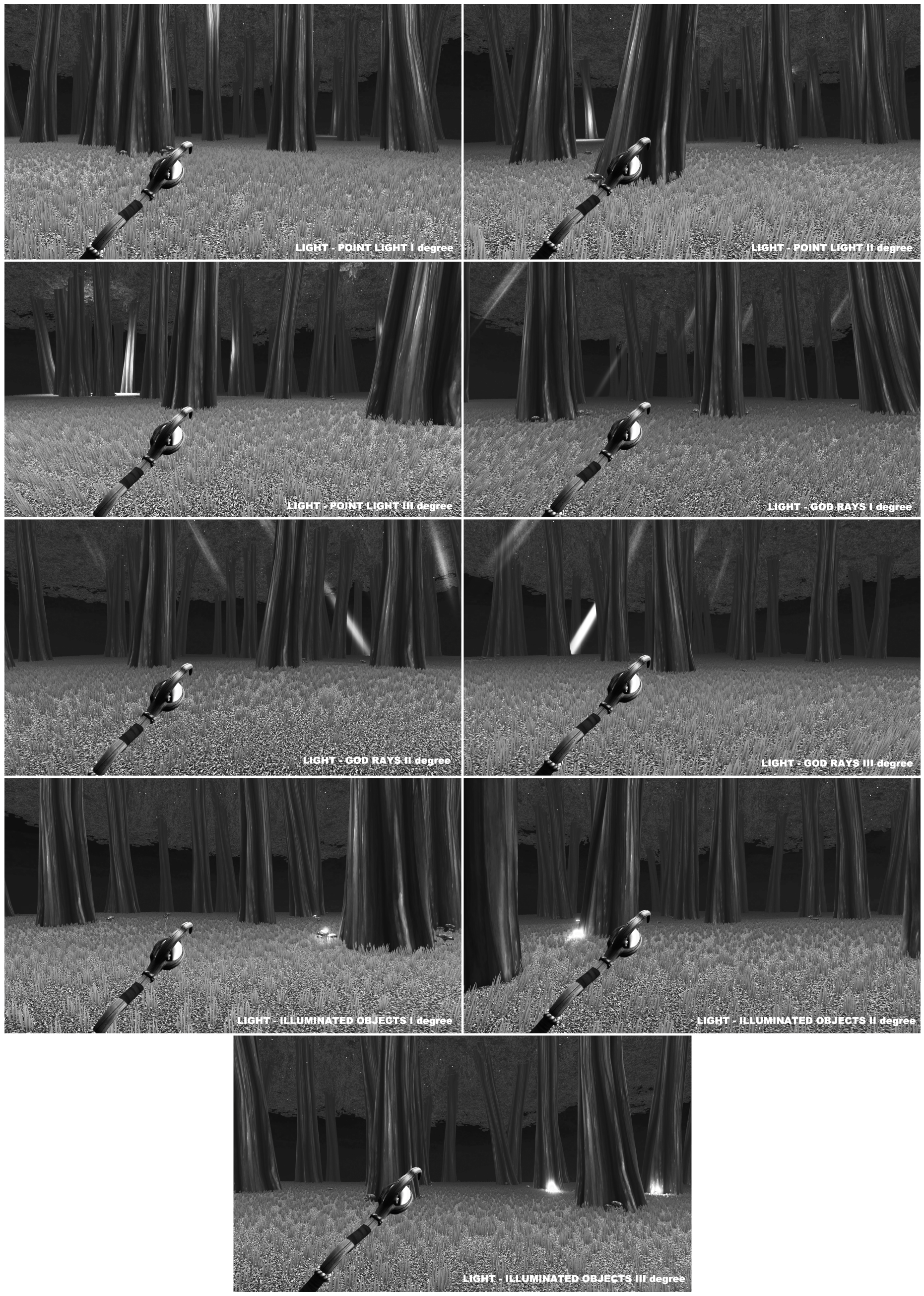

Fig. 1. Views from starting points on levels implementing light methods.

ICCS Camera Ready Version 2025
To cite this paper please use the final published version:
DOI: 10.1007/978-3-031-97573-8_5

3.2 Methods

Two types of visual cues were used in the work. One based on light and the other based on geometry. Each type has three variations in three degrees of intensity. Both types will be explained below.

Light The light-based visual cues employed in this study consisted of point lights, god rays, and illuminated objects distributed along the path. Further descriptions of the lighting parameters will be provided in terms of the contrast between the environment and the light, quantified as a percentage based on the color brightness derived from the lightness parameter in the HSL model. Given that the environment was devoid of color, the hue and saturation parameters remained constant at 0, with only the lightness parameter being relevant for contrast calculations. For instance, the color notation (0,0,14) in the HSL model would be represented as 14% brightness.

Each level incorporating a point light features a designated illuminated spot for the player to reach. In the case of god rays, these rays are directed towards the target spot. For the illuminated object variant, small glowing mushroom models were placed along the path, with their arrangement guiding the player to the destination (Fig. 1). For each of the methods tested, three levels of intensity were applied, determined by the corresponding difference in brightness between the light source and its immediate surroundings. These intensity levels are differentiated by increasing contrast values, as presented in Table 1.

Table 1. The difference in pixel brightness between a particular variant and the surroundings expressed as a percentage in light method. The difference in models between a particular variant in geometry method.

Light			
-	Point light	God rays	Illuminated objects
I degree	6%	5%	6%
II degree	11%	9%	12%
III degree	21%	20%	27%
Geometry			
-	Rotation	Scale	Shape
I degree	$15°$	scale x2	4 branches
II degree	$30°$	scale x3	8 branches
III degree	$60°$	scale x4	16 branches

Geometry The visual cue variants based on geometry involve modifying a parameter of a tree object commonly used in the environment. The parameters subject to modification include rotation, scale, and shape of the object. The specific values for each of these altered parameters are detailed in Table 1.

ICCS Camera Ready Version 2025
To cite this paper please use the final published version:
DOI: 10.1007/978-3-031-97573-8_5

In levels associated with the study of the effect of object rotation on player navigation, a single tree is distinguished by its tilt angle. The tilted object is rotated along a single axis such that it aligns with the player's initial viewpoint. The tilt angle for the pattern in its first degree is set to 15 degrees, with subsequent tilt angles doubling the previous value.

Levels featuring the scale-related variant include a single tree that has been enlarged. The default scale for all other trees is set to 1. The pattern strength for I degree is defined by a scale value that is twice the size of the default tree's scale. Subsequent degrees of intensity increase linearly by one unit.

The stages of the study examining the impact of object shape on player behavior each feature a single tree with modifications to its geometric shape, specifically in relation to the branches. To ensure that the modified tree stands out in contrast to the simple trunks of other trees, all non-pattern trees in these levels have a single branch. I Degree of the pattern strength involves four branches evenly distributed on each side of the tree. In subsequent degrees, the number of branches doubles with each increase (Fig. 2).

3.3 Collected Data

For the purposes of this study, a player tracking system was developed, drawing inspiration from, among other sources, a data collection system described in research on visual attention in interactive environments, particularly in relation to task performance [4]. During the exploration of each level, data samples are collected at regular intervals, recording the following information: the player's position, the camera's rotation, and whether the object implementing the method under study was within the player's view. The data gathered through this process enables the precise reconstruction of each participant's gameplay, allowing for a comprehensive and unrestricted analysis. Upon completion of the study, which involves navigating and completing all the designed levels, participants are also required to fill out a questionnaire intended to complement and further inform the study's findings.

4 Participants

The survey included 36 participants: 26 men and 10 women. Most respondents (83.3%) were aged 21-25, followed by 8.3% aged 26-30, 5.6% aged 16-20, and 2.8% aged 31-35. Weekly time spent playing computer games varied: 41.7% played 10-20 hours, 30.6% played less than 5 hours, 16.7% played 5-10 hours, and 11.1% played more than 20 hours.

Participants were categorized into two groups based on gaming activity: casual gamers (up to 10 hours/week, 47% of respondents) and hardcore gamers (more than 10 hours/week, 53% of respondents).

ICCS Camera Ready Version 2025
To cite this paper please use the final published version:
DOI: 10.1007/978-3-031-97573-8_5

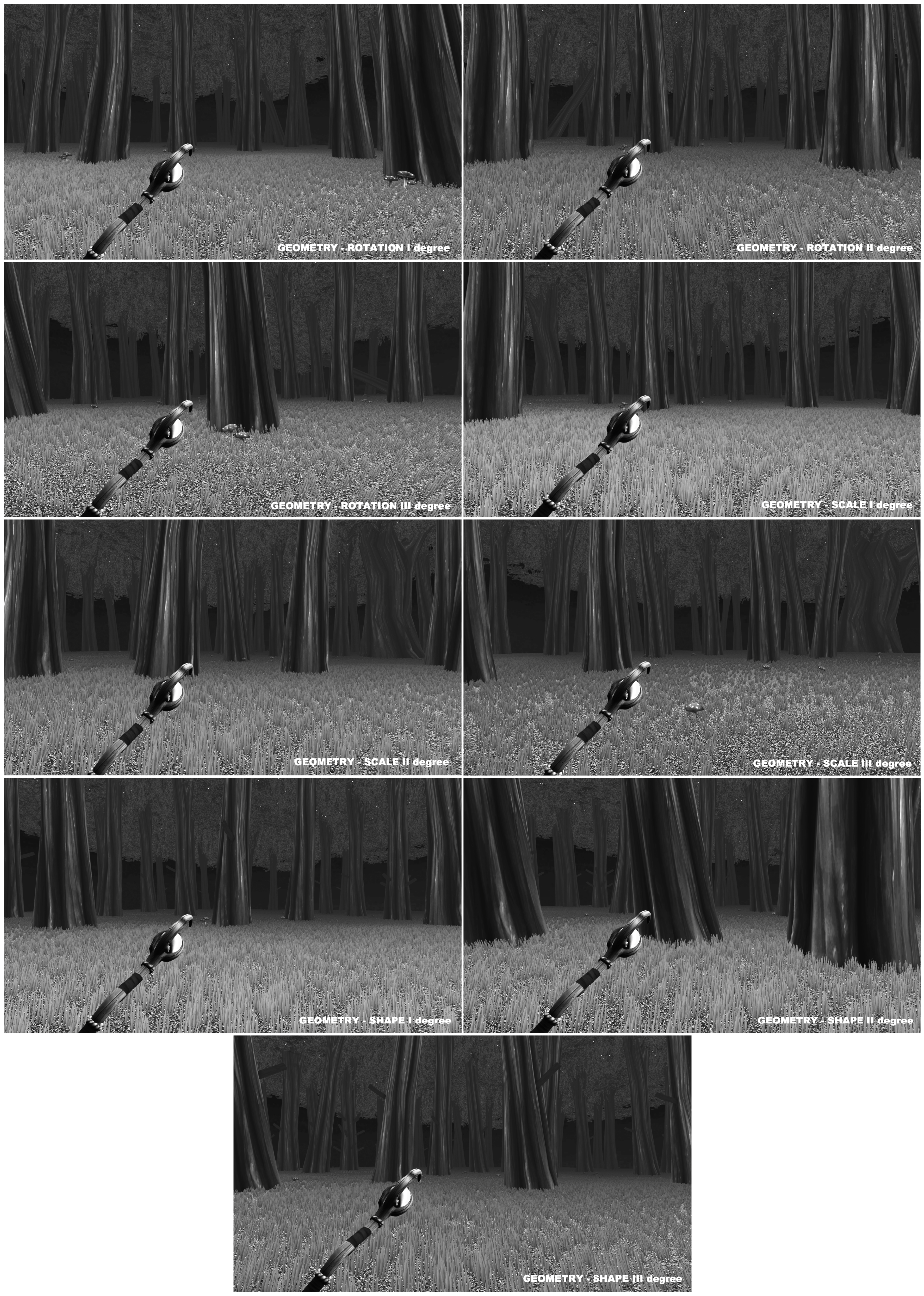

Fig. 2. Views from starting points on levels implementing geometry methods.

ICCS Camera Ready Version 2025
To cite this paper please use the final published version:
DOI: 10.1007/978-3-031-97573-8_5

5 Results

In response to the first optional question of the questionnaire, which asked participants to identify the methods they noticed, 34 out of 36 respondents provided answers. The methods noticed by the participants were categorized as follows: Illuminated objects: Noticed by 25 participants; God rays: Noticed by 23 participants; Point light: Noticed by 13 participants; Rotation: Noticed by 32 participants; Scale: Noticed by 28 participants;Shape: Noticed by 20 participants.

As evident from these responses, the most frequently noticed method was the rotation variant.

During the exploration of each level, data samples were collected at regular intervals, documenting the player's position, camera rotation, and the visibility of the method on the player's screen. For this study, samples were collected every half second.

To assess the visibility of each method during the test, a parameter was developed. This visibility parameter represents the total duration (in percentage) that the method was visible in the central area of the participant's screen during a given level. All samples collected throughout the test are included in the calculation. This approach allows for the determination of the cumulative time that the method was visible while the participant progressed through the level. A summary of all the results collected during the survey can be found in Table 2.

6 Discussion

This chapter analyzes the collected data through graphical maps of player routes and calculated parameters, evaluating the impact of each method and variant.

6.1 Light

The point light variant showed increasing effectiveness with higher degrees of implementation. At the weakest level (I), visibility was only 63.5%, with many participants failing to notice the contrasting light source, resulting in arbitrary exploration. Level II demonstrated a significant improvement, achieving a 92.7% visibility rate, with most participants immediately navigating toward the illuminated portal. Level III results were comparable to level II, confirming the method's reliability at higher strengths. The god ray variant was initially less effective, with a level I visibility rate of 59.3%, as participants often failed to detect the subtle light beams. Level II visibility improved to 85.5%, and level III reached 96.1%, demonstrating its effectiveness when implemented with stronger contrast. The illuminated objects variant proved the least effective of the light-based methods. Visibility ranged from 70.5% at level I to 79.6% at level III, with only minor improvements across variants. Players frequently overlooked the illuminated objects, resulting in disorganized navigation and minimal impact on exploration.

ICCS Camera Ready Version 2025
To cite this paper please use the final published version:
DOI: 10.1007/978-3-031-97573-8_5

Table 2. A table summarizing the results for each Light and Geometry variant and degree of strength. Visibility is the average percentage of how long the method was visible on the users' screen. While time is the average of the times of each user.

Point light					Rotation				
I degree	Visibility	σ	Time	σ	I degree	Visibility	σ	Time	σ
all players	63.5%	2.5	21.5s	3.2	all players	55.9%	1.9	49.4s	4.7
casual	57.7%	3.7	27.3s	6.7	casual	53.7%	2.2	53.4s	5.3
hardcore	68.1%	2.8	17s	1.5	hardcore	57.9%	1.4	45.9s	4
II degree	Visibility	σ	Time	σ	II degree	Visibility	σ	Time	σ
all players	92.7%	1.4	11.6s	1.4	all players	80%	1.9	24.6s	1.7
casual	93.7%	1.5	14.8s	3	casual	80.7%	1.9	24s	1.1
hardcore	92%	2.1	9.2s	0.2	hardcore	79.4%	1.9	25.2s	2.1
III degree	Visibility	σ	Time	σ	III degree	Visibility	σ	Time	σ
all players	85.6%	1.5	9.3s	0.5	all players	88%	1.7	26.3s	1.7
casual	84.2%	2.1	10.7s	0.9	casual	87.2%	1.6	28.3s	1.6
hardcore	86.6%	2.1	8.2s	0.2	hardcore	88.7%	1.7	24.5s	1.8
God rays					Scale				
I degree	Visibility	σ	Time	σ	I degree	Visibility	σ	Time	σ
all players	59.3%	4.4	25.3s	2.8	all players	53.5%	2.1	69.9s	6.3
casual	61%	6.9	25s	3.8	casual	49.9%	2.2	89.8s	6.4
hardcore	58%	5.7	25.6s	4.1	hardcore	56.8%	2	52.1s	5.6
II degree	Visibility	σ	Time	σ	II degree	Visibility	σ	Time	σ
all players	85.5%	2.8	13.2s	1	all players	68%	2.1	60s	17.2
casual	85.3%	4.1	15.6s	1.6	casual	65.4%	2.1	99.3s	24.4
hardcore	85.7%	3.9	11.3s	1.1	hardcore	70.4%	2.1	24.9s	1.5
III degree	Visibility	σ	Time	σ	III degree	Visibility	σ	Time	σ
all players	96.1%	1.5	10.3s	0.9	all players	87.7%	1.3	28.8s	2.8
casual	96.6%	1.6	12.2s	1.9	casual	88.2%	1.4	34s	4
hardcore	98.7%	2.3	8.8s	0.1	hardcore	87.1%	1.2	24.1s	0.5
Illuminated objects					Shape				
I degree	Visibility	σ	Time	σ	I degree	Visibility	σ	Time	σ
all players	70.5%	3.8	26.1s	5.8	all players	44.1%	1.6	68.7s	5.1
casual	69.7%	6	35.9s	11	casual	44.4%	1.6	66.7s	4.7
hardcore	71%	4.8	18.3s	5.1	hardcore	43.8%	1.7	70.4s	5.3
II degree	Visibility	σ	Time	σ	II degree	Visibility	σ	Time	σ
all players	79%	3.7	28.2s	7.3	all players	56.1%	2.1	57.8s	5.8
casual	71.7%	5.9	32.1s	11.8	casual	59.5%	2.2	60.1s	6
hardcore	84.8%	4.3	25.2s	9.1	hardcore	53%	1.9	55.6s	4.4
III degree	Visibility	σ	Time	σ	III degree	Visibility	σ	Time	σ
all players	79.6%	2.5	21.6s	13.4	all players	73.9%	2.5	30.6s	3.2
casual	75.3%	4.3	38.9s	29.9	casual	76%	2.5	35.9s	3.8
hardcore	83%	2.7	8s	0.9	hardcore	72%	2.6	25.9s	2.4

ICCS Camera Ready Version 2025
To cite this paper please use the final published version:
DOI: 10.1007/978-3-031-97573-8_5

6.2 Geometry

The rotation variant demonstrated clear improvements in effectiveness with increasing degrees. At level I, visibility was 55.9%, and players often failed to notice the leaning object. At level II, visibility rose to 80%, with clearer navigation paths emerging. Level III achieved 88% visibility, demonstrating strong influence on player behavior. The scale variant followed a similar pattern, with visibility improving from 53.5% at level I to 87.7% at level III, suggesting it became effective only at its strongest implementation. The shape variant was the least impactful. Visibility ranged from 44.1% at level I to 56.1% at level II, with minimal improvements even at level III. The added branches to differentiate the object failed to consistently attract attention, highlighting the method's limited salience.

6.3 Impact of the Player Type

The influence of player experience was analyzed by comparing casual and hardcore players. For point light, hardcore players completed levels faster, averaging one-third less time than casual players at level I, though visibility rates were 10% lower, reflecting their focused navigation. At levels II and III, results were similar for both groups, with visibility exceeding 90% and differences primarily in completion times. The god ray method showed similar trends across groups, with both casual and hardcore players achieving high visibility rates at stronger levels, though hardcore players consistently completed levels more quickly.

The illuminated objects variant revealed marked differences: hardcore players completed level I nearly twice as fast as casual players, and their performance continued to improve across variants, while casual players struggled to interpret the method effectively. For geometry-based cues, hardcore players generally outperformed casual players in both completion time and navigation efficiency. However, at the strongest level of the shape variant, casual players unexpectedly outperformed hardcore players, achieving better visibility and faster completion times. This suggests that the shape-based method may be less intuitive for experienced players, potentially due to over-exploration or misinterpretation of cues.

These findings emphasize the importance of tailoring navigation methods to account for player experience and highlight the effectiveness of stronger visual cues in guiding both casual and hardcore players.

7 Conclusions

The objective of this study was to evaluate and compare the effectiveness of visual methods for guiding player behavior during exploratory tasks. The survey, conducted with 36 participants, demonstrated that the influence of these methods on players' decision-making is significantly affected by the strength of the visual cues.

The effectiveness of light-based methods was quantified through the difference in average pixel brightness between the highlighted area intended to attract

ICCS Camera Ready Version 2025
To cite this paper please use the final published version:
DOI: 10.1007/978-3-031-97573-8_5

the player's attention and its surrounding environment. A critical threshold for contrast was identified at 10% brightness difference in the HSL color model, beyond which a notable improvement in players' navigation behavior was observed. This finding aligns with values reported in existing literature, where contrast has been analyzed in the context of other visual guidance techniques.

Parametric and visual analysis of player movement routes revealed that the most effective geometric method was rotation, followed by scale, while shape-based methods had the least influence. Furthermore, thresholds were identified for the strength of these geometric methods, indicating when they begin to meaningfully impact players' attention. For instance, the rotation method proved effective at a 30-degree tilt, while the scale method only became impactful at its maximum strength, where objects were six times larger than others in the scene. Shape-based methods, even at their strongest degree, did not reliably assist in player navigation.

A comparison of results across casual and experienced players reinforced the universality of these visual methods. Both groups responded similarly to the tested techniques, suggesting their applicability across different player demographics.

It is important to note the potential influence of player curiosity during initial levels, which may diminish the observed effectiveness of weaker variants of the methods. This curiosity-driven exploration could obscure the methods' true impact at lower intensities.

An important limitation of the study design is the fixed order in which cue intensities were presented—each method was always tested from weakest to strongest. While this approach reflects a natural learning curve and ensures that stronger cues are not prematurely introduced, it may also introduce an order effect. Specifically, participants may become increasingly familiar with the game mechanics or the visual language of the environment as they progress, potentially improving their ability to detect cues regardless of their strength. Additionally, the initial exposure to weaker cues may have been influenced by elevated curiosity and exploratory behavior, which could obscure the actual effectiveness of these cues. Counterbalancing the order of intensity levels across participants would have mitigated these effects and strengthened the validity of the results, although it would have introduced additional complexity into the experimental design. Future studies may consider randomized or balanced cue sequences to better isolate the impact of cue strength from learning or habituation effects.

Finally, the use of a controlled, homogeneous environment in this study allows for the generalization of results to other settings with different environmental elements. Future research could explore the applicability of these findings in more varied contexts, offering additional insights into the robustness of these visual guidance techniques.

While the results presented in this study are promising, it is essential to consider certain limitations that may affect the validity of the findings. One potential threat to internal validity is the influence of participants' prior gaming experience or expectations, which may have shaped how they perceived and

ICCS Camera Ready Version 2025
To cite this paper please use the final published version:
DOI: 10.1007/978-3-031-97573-8_5

responded to the cues. Although the test environment was intentionally simplified to control for external variables, the stylized and homogeneous design may reduce ecological validity compared to real-world game settings, where players encounter more complex visual and narrative contexts. Additionally, the short duration of the experimental sessions may not fully capture how players adapt to visual cues over extended gameplay. Future research should aim to validate these findings in more immersive and varied environments, incorporating longer play sessions and more diverse participant groups to strengthen the generalizability of the conclusions.

Acknowledgements This article has been completed while the third author was the Doctoral Candidate in the Interdisciplinary Doctoral School at the Lodz University of Technology, Poland.

References

1. Alexander, C.: A pattern language: towns, buildings, construction. Oxford university press (1977)
2. Barney, C.: Pattern language for game design. CRC Press (2020)
3. Gómez-Maureira, M.A., Kniestedt, I., Van Duijn, M., Rieffe, C., Plaat, A.: Level design patterns that invoke curiosity-driven exploration: An empirical study across multiple conditions. Proceedings of the ACM on Human-Computer Interaction **5**(CHI PLAY), 1–32 (2021)
4. Hadnett-Hunter, J., Nicolaou, G., O'Neill, E., Proulx, M.: The effect of task on visual attention in interactive virtual environments. ACM Transactions on Applied Perception (TAP) **16**(3), 1–17 (2019)
5. Hoeg, T.: The invisible hand: Using level design elements to manipulate player choice. Masters of Interactive Technology in Digital Game Development with a Specialization in Level Design, Guildhall at Southern Methodist University (2008)
6. Irshad, S., Perkis, A., Azam, W.: Wayfinding in virtual reality serious game: An exploratory study in the context of user perceived experiences. Applied Sciences **11**(17), 7822 (2021)
7. Knez, I., Niedenthal, S.: Lighting in digital game worlds: Effects on affect and play performance. CyberPsychology & Behavior **11**(2), 129–137 (2008)
8. Kremers, R.: Level design: concept, theory, and practice. CRC Press (2009)
9. Liszio, S., Masuch, M.: Lost in open worlds: design patterns for player navigation in virtual reality games. In: Proceedings of the 13th International Conference on Advances in Computer Entertainment Technology. pp. 1–7 (2016)
10. Marples, D., Gledhill, D., Carter, P.: The effect of lighting, landmarks and auditory cues on human performance in navigating a virtual maze. In: Symposium on Interactive 3D Graphics and Games. pp. 1–9 (2020)
11. Moura, D., El-Nasr, M.S.: Design techniques for planning navigational systems in 3-d video games. Computers in Entertainment (CIE) **12**(2), 1–25 (2015)
12. Petersson, E., Helgesson, F.: Visual attention in level design for a 3d adventure platform game-analyzing visual cues in a 3d environment (2018)
13. Rogers, S.: Everything i learned about level design i learned from disneyland. In: Game Developers Conference (2009)

ICCS Camera Ready Version 2025
To cite this paper please use the final published version:
DOI: 10.1007/978-3-031-97573-8_5

14. Totten, C.W.: Architectural Approach to Level Design. CRC Press (2019)
15. Winn, B.M., Peng, W., Pfeiffer, K.: Player guiding in an active video game. In: 2011 IEEE International Games Innovation Conference (IGIC). pp. 107–108. IEEE (2011)
16. Winters, G.J., Zhu, J.: Guiding players through structural composition patterns in 3d adventure games. In: FDG (2014)
17. Yesiltepe, D., Conroy Dalton, R., Ozbil Torun, A.: Landmarks in wayfinding: a review of the existing literature. Cognitive processing **22**, 369–410 (2021)

ICCS Camera Ready Version 2025
To cite this paper please use the final published version:
DOI: 10.1007/978-3-031-97573-8_5