Game Level Design to Evoke Spatial Exploration: The Influence of a Secondary Task

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Abstract

In open-world games, focusing on triggering the spatial exploration of the environment is crucial for engaging player experiences. Triggering players' spatial exploration can be achieved by evoking curiosity, a fundamental driving force behind game explorations. In this paper, we present the results of our pilot study in which we investigated the impact of secondary tasks, specifically coin collection, on player behavior and satisfaction within an open-world game. We used a procedural content generation algorithm to synthesize game levels with low and high spatial exploration targets. Later, we conducted a 2 (Spatial Exploration: low vs. high) × 2 (Coins: with vs. without) between-group study ($N = 28$) to validate how a secondary task (coin collection) could impact spatial exploration. Our findings reveal that the coins diminish players' spatial exploration, as spatial exploration scores and visited occupied cells decreased. Surprisingly, players expressed higher personal gratification when engaged with levels designed with low spatial exploration targets compared to those with higher spatial exploration targets, challenging our initial assumptions. We plan to conduct a large-scale study to validate these initial observations and explore additional metrics influencing gameplay engagement.

CCS Concepts

• **Software and its engineering → Interactive games**; • **Human-centered computing → User studies**.

Keywords

Spatial Exploration, Curiosity, Game Level, Secondary Task, Reward, Coins

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1 Introduction

Focusing on players' interests and actions is crucial when designing a game level. Moreover, guiding the player through a level based solely on the designer's intentions can be challenging for users [20]. However, achieving the desired goal of a designed game level often requires a trial-and-error design process. Thus, game designers have employed various strategies to control design aspects and improve gameplay effectiveness. One such strategy is using procedural content generation (PCG) algorithms. PCG facilitates the creation of (semi-) automatic game content, aiding designers by producing more content in less time through well-defined computational procedures [2, 11, 15–17]. Additionally, PCG allows designers to parameterize and control different game level metrics to address players' needs and characteristics. Metrics such as player behavior, proposed by Togelius et al. [24], can generate levels based on players' gameplay data. Similarly, Washburn and Khosmood [27] designed a tool to generate music for NPCs, according to their roles in a 2D adventure game, to enhance player immersion.

Among the parameters that can trigger players' interest in games, we focused on the concept of curiosity. Curiosity is critical to engaging players in games [13]. From a psychological perspective, researchers defined curiosity as an inherent preference for the uncertainty between the known and unknown [14]. In games, evoking curiosity can lead to greater interest and exploration of the game environment. Researchers have explored using curiosity as a design element for game levels and its effects on players' engagement [1, 9].

Considering a previous work regarding curiosity design patterns [10] and our proposed method that generates game levels focused on spatial exploration in open-world games [1], we aim to evaluate if including an alternative task, such as collecting coins (see Fig. 1), could affect players' time spent interacting with the game and their satisfaction. Thus, we conducted a 2 (Spatial Exploration: low vs. high) × 2 (Coins: with vs. without) between-group study ($N = 28$). We asked participants to play an open-world game level, exploring the environment for 10 minutes. Depending on the experimental condition, we included or did not include coins in the game levels. We collected in-game data to measure participants' time spent on each cell of the 2D grid that defined the game level and gathered

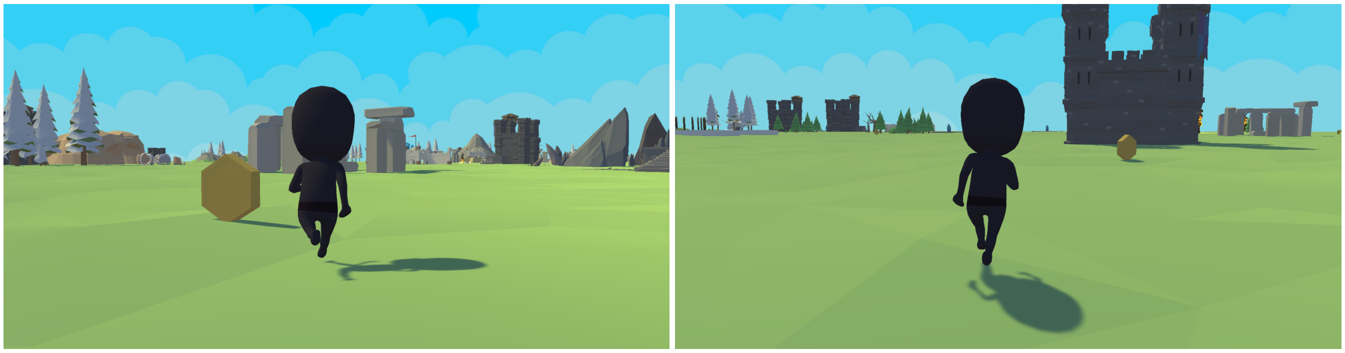

Figure 1: We conducted a study to explore how players explore an open-world game level while encountering secondary tasks (i.e., collecting coins) to reward them.

data through a self-reported survey after the game. With this pilot study, we aimed to gain insights into our potential results, validate the research design, optimize inputs, and assess the selected game levels. We do this by answering the following research questions:

- **RQ1:** Does a secondary task (i.e., collecting coins) affect participants' spatial exploration behavior in an open-world game?
- **RQ2:** Does a secondary task (i.e., collecting coins) affect user experience satisfaction in an open-world game?

We organized the remainder of this paper into the following sections. In Section 2, we described previous work on procedural content generation and how researchers have conceived curiosity in games. In Section 3, we described details surrounding the conducted experiment design, such as the participants, the employed games, the experimental conditions, and the collected measurements. In Section 4, we provide a report of the results of the conducted study. Finally, in Section 5, we discuss the findings and provide insights for future works.

2 Related Work

Curiosity in games is often exploited through game assets, which are 3D objects that compose the game environments (e.g., trees, settlements) that attract players and encourage them to explore the environment. Gómez-Maureira et al. [10] empirically studied how level design patterns influence spatial exploration in 3D open-world games, providing evidence-based insights into how design patterns evoke a desire to explore. Tang and Kirman [23] recently designed a questionnaire to address curiosity in games, considering different kinds of curiosity defined by psychological aspects such as perceptual, manipulatory, epistemic, social, and rewards. They conducted and validated their questions with a more extensive user study with gamers and their previous experiences with commercial games.

Furthermore, using rewards in games is common to define game levels and evoke exploration. Including the task of collecting treasure, currencies, or power-ups is a well-known technique that evokes user exploration [4]. Researchers have been testing rewards on games in different aspects, such as Denisova and Cook [5], who found that power-ups temporarily grant players extra abilities or skills and can enhance gaming experience and performance. However, they noted the persuasive nature of these elements. Regarding different reward mechanisms, Siu and Rield [21] conducted a study evaluating the use of varying reward mechanisms such as global leaderboards, customizable avatars, unlockable narratives, and global progress trackers, finding that allowing players to choose their rewards leads to better task completion and a more engaging experience.

For this project, we developed our games using a PCG method. Game designers used PCG to generate game content, such as maps, quests, characters, or textures. This paradigm has interested the game development community, with many games incorporating some form of level generation. Researchers have applied PCG to various aspects of game level design. For instance, Guérin et al. [8] developed an authoring tool that generates terrain based on simple outlines, including mountains, rivers, and erosion. Green et al. [7] explored the creation of dungeons by implementing multiple algorithms to generate content for *MiniDungeons 2*, defining the layout, paths of playable tiles, and positioning elements like exits, treasures, potions, portals, and monsters. Khalifa et al. [12] developed a machine learning model for mazes that imitates an evolutionary approach to generate a 2D maze layout. Similarly, Song and Whitehead [22] created TownSim, an agent-based city evolution algorithm for road network layouts.

PCG techniques often employ refined algorithms to achieve designers' goals and capture user attention. Van der Staaij et al. [25] used artificial intelligence (AI)-driven agents to generate city settlements in *Minecraft*, simulating city formation and placement of elements such as roads, walls, farms, trees, water, decorations, and churches. Beukman et al. [3] used evolutionary search-based methods and reinforcement learning to create 2D platformer levels like those in *Super Mario Bros*. Sarkar et al. [19] explored machine learning techniques for learning transfer between different game problem spaces using methods such as autoencoders, Bayesian networks, and multidimensional Markov chains.

Finally, in our previous work [1], we proposed a method for synthesizing game levels to encourage specific exploration goals. We developed an algorithm that defines a game level layout for open-world games, controlling the degree of spatial exploration to represent different levels of exploration intensity. As an extension of that work, we aim to validate whether including a secondary task, such as collecting coins, affects the primary objective of spatial exploration. This study seeks to provide insights into how the inclusion of rewards can impact user performance, exploration behavior, and time spent interacting with game assets. This information could help designers and researchers enhance user engagement in open-world games.

3 Experiment

3.1 Participants

For this initial pilot study, we recruited 28 participants (seven per condition) who volunteered to play our game (age: M = 21.54, SD = 4.19). Of the sample, 17 participants were male, 10 were female, and one preferred not to disclose their gender. Additionally, 39% considered expert players, 35% as casual, 18% as core, and 7% as novice. Most of the participants played video games in the last year for more than an hour per day (46%), followed by one hour per day (21%), and the rest of them stated that they played fewer hours during the year (33%).

3.2 Open-world Game Level

3.2.1 Spatial Exploration. In this paper, we defined spatial exploration as the players' total time spent exploring a game asset. For our study, we employed an open-world game with multiple assets previously annotated to catch the player's attention. These assets are defined based on the exposed design patterns in Gómez-Maureira and Kniestedt [10] study and are the following:

- **Reaching Extreme Points (EXP):** Games that encourage exploration often feature locations considerably higher than the rest of the game environment.
- **Resolving Visual Obstructions (OBS):** Parts of a game environment can be deliberately obscured to motivate exploration.
- **Out-of-Place (OOP):** Out-of-place elements are game objects that stand out in the context in which they are placed.
- **Understanding Spatial Connections (SPC):** Games that allow players to navigate an environment might feature complex, interconnected paths.

We implemented our games using the assets and the PCG algorithm presented in our previous work [1]. In that work, we proposed and evaluated an optimization method that generates game levels that follow designer-specified spatial exploration targets, asserting the final exploration goal of the players. Our methods include different inputs to control the generation of the levels, such as the Mean Spatial Exploration Cost (ρ_M), which refers to the overall spatial exploration from all used assets for the level and the Occupied Area Cost (ρ_{OA}) to control how crowded the level can be. Using this method, we generated two game levels targeting two types of spatial exploration: low (ρ_M = .25) and high (ρ_M = .75). All other inputs were kept at their default settings, as described in our previous paper. In Fig. 2, we illustrate the generated level heat maps based on the annotated game assets and their spatial exploration degree. The game levels consisted of a 25×25 grid size. Each grid cell was 25×25 Unity units in size, with assets distributed around the environment based on their defined spatial cost and level design cost criteria.

3.2.2 Coins Placement. With the defined game level and the expected spatial exploration goal, we included coins to compare player performance with and without an additional task. We placed 20 coins in the game level to draw the player's attention beyond the primary game assets. In low (LSC) and high (HSC) spatial exploration levels, we placed these coins in "empty spots" outside the main asset areas. The coin placement was consistent across both game levels, as shown in Fig. 2. Additionally, we initiated the player's avatar position in an empty spot randomly chosen at the beginning of the game, so the players' initial view of the level will differ each time.

3.2.3 Instruction. In the game, we included instructions to guide the user toward the objective of the gameplay. We instructed our participants to explore the game level as much as possible, driven by their curiosity through the game level assets in the open-world environment. To avoid any potential bias from the instructions serving as a guided goal, we provided the following instructions:

> *Welcome to this game! You have 10 minutes to explore the level. Use* WASD *for movement, press the spacebar key to jump, and use the mouse to control the camera's rotation. The system will inform you once 10 minutes have passed. Press the* X *button to play.*

We should note that we did not display a coin counter to ensure players received the same information regardless of whether we included rewards (coins) or not. This way, we instructed all players to explore the level freely, with the secondary task of collecting coins being optional and not emphasized.

3.3 Experimental Conditions

We employed a 2 (Spatial Exploration: low vs. high) × 2 (Coins: with vs. without) between-group design. Considering the two different game levels we defined based on the low and high spatial exploration scores, we aimed to evaluate the inclusion of the alternative task of collecting coins on the already delimited exploration task in the game. Thus, we evaluated the following four conditions:

- **Low Spatial Exploration without Coins (LSE):** We exposed our participants to a low spatial exploration game level without including coins.
- **Low Spatial Exploration with Coins (LSEC):** We exposed our participants to a low spatial exploration game level, including coins.
- **High Spatial Exploration without Coins (HSE):** We exposed our participants to a high spatial exploration game level without including coins.
- **High Spatial Exploration with Coins (HSEC):** We exposed our participants to a high spatial exploration game level, including coins.

The participants were distributed as follows: for the LSE condition there were five males, one female, and one did not prefer to say (age: M = 22.43, SD = 4.16); for the LSEC condition there were six males and one female (age: M = 22.43, SD = 5.740); for the HSE condition there were four females and three males (age: M = 19.29, SD = 0.95); and for the HSEC condition there were four

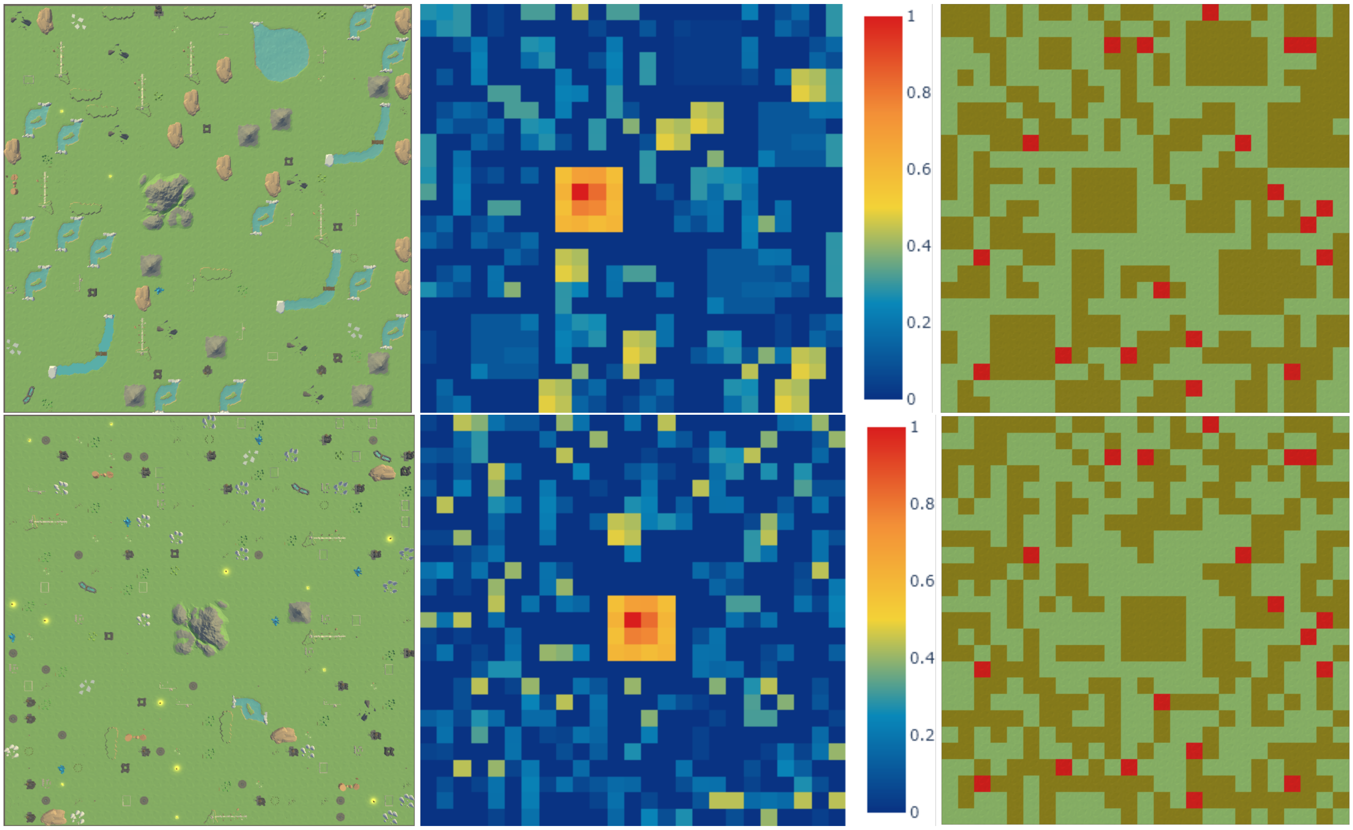

Figure 2: The two game levels we used in our study (lefts), their heatmaps illustrating spatial exploration (middle), and the placement of the coins indicated in red (right): (top) low and (bottom) high spatial exploration.

females and three males (age: $M = 22.00$, $SD = 4.43$). Regarding video game play experience, the LSE condition had 71.43% experts, 14.29% casual, and 14.29% core players, with no novices. In the LSEC condition, 42.86% were casual, 42.86% were core, and 14.29% were experts, with no novices. For the HSE condition, 42.86% were experts, 42.86% were casual, and 14.29% were novices, with no core players. Lastly, in the HSEC condition, 42.86% were casual players, 28.57% were experts, 14.29% were core, and 14.29% were novices.

3.4 Measurements

We collected data on participants' spatial exploration (SEF) behavior. To collect these data, we used the position of the player's avatar and computed its time spent inside each grid cell of the game level. The more time a player spent from the total game time inside a cell, the more curious they were to explore the asset of that cell. For example, if a player spent two out of the total 10 minutes in cell (4, 4), it likely indicates a significant interest in the content placed in that cell due to spending 20% of the total time inside that cell. We also computed an "exploration score" (SCORE). For the SCORE, we first computed the number of occupied cells with game assets a player visited. Then, we computed the ratio between the visited occupied cells over the total number of occupied cells at the game level. We also collected self-reported ratings through a post-game survey that we distributed to our participants. With this survey, we collected demographic information. We also selected measurements from the Game User Experience Satisfaction Survey (GUESS) [18], including aspects of gaming experiences such as enjoyment (ENJ), creative freedom (CRE), play engrossment (ENGR), and personal gratification (GRAT).

3.5 Procedure

For our preliminary data collection, we conducted a remote study. Specifically, we emailed participants instructions on how to download our game and complete the study. The instructions included step-by-step information on executing the game, what files needed to be sent (a `.csv` file with user performance), and the corresponding online survey link in Qualtrics, the online survey tool we used for our study. After downloading the game and before completing the study, we asked participants to consent to participate by signing an online form. Once the participants agreed and proceeded to execute the game, the system automatically randomly assigned them to one of our experimental conditions.

Participants played our game for 10 minutes. Upon completion of the gaming session, each participant filled out the online survey. This survey included demographics-related questions such as gender, age, type of video game player, how often they played games in the last year, and the GUESS questionnaire. Finally, the survey also instructed participants to use an "upload" button to upload the `.csv` file generated during their gameplay immediately after they pressed the `X` key. After submitting their survey responses, participants were free to play our game as long as they wished but without making duplicate submissions.

4 Results

We used a two-way analysis of variance (ANOVA) to explore potential differences across the experimental conditions. We validated the normality of the data using Shapiro-Wilk tests at the 5% level and the Q-Q plots of the residuals. We used a p-value of $< .05$ to denote statistical significance. We performed the statistical analyses using IBM's SPSS software version 25 and summarized the results in Table 1.

4.1 Spatial Exploration

4.1.1 Spatial Exploration Factor (SEF). We found no statistically significant main effect for the spatial exploration factor ($F[1, 27] = .040$, $p = .843$). However, our simple main effect analysis on coins ($F[1, 27] = 85.874$, $p < .001$) showed that participants spent less time exploring the game level assets when the level includes coins ($M = 51.19$, $SD = 5.89$) than levels without coins ($M = 71.76$, $SD = 5.93$). Nevertheless, we did not find a statistically significant spatial exploration × coins interaction effect ($F[1, 27] = 2.248$, $p = .147$).

4.1.2 Exploration Score (SCORE). Regarding the exploration score, we found no statistically significant main effect for the spatial exploration factor ($F[1, 27] = .644$, $p = .430$). However, our simple main effect analysis on coins ($F[1, 27] = 7.932$, $p = .010$) showed that participants visited fewer cells occupied with game level assets when the level includes coins ($M = 83.14$, $SD = 8.55$) than the levels without coins ($M = 68.36$, $SD = 17.12$). Nevertheless, we did not find a statistically significant spatial exploration × coins interaction effect ($F[1, 27] = .022$, $p = .882$).

4.2 GUESS Survey

4.2.1 Enjoyment (ENG). We found no statistically significant main effect for the spatial exploration factor ($F[1, 27] = 1.939$, $p = .177$), for the coins factor ($F[1, 27] = .008$, $p = .931$), and for the spatial exploration × coins interaction effect ($F[1, 27] = 2.735$, $p = .111$).

4.2.2 Creative Freedom (CRE). We did not find a statistically significant main effect for the spatial exploration factor ($F[1, 27] = 2.592$, $p = .120$), the coins factor ($F[1, 27] = .648$, $p = .429$), or the spatial exploration × coins interaction effect ($F[1, 27] = .648$, $p = .429$).

4.2.3 Play Engrossment (ENGR). We found no statistically significant main effect for the spatial exploration factor ($F[1, 27] = 2.035$, $p = .167$), the coins factor ($F[1, 27] = .106$, $p = .748$), or the spatial exploration × coins interaction effect ($F[1, 27] = 2.181$, $p = .153$).

4.2.4 Personal Gratification (GRAT). Our simple main effect analysis on the spatial exploration factor ($F[1, 27] = 5.109$, $p = .033$) showed that participants rated their perceived motivation for playing the game higher when they played the low spatial exploration level ($M = 4.63$, $SD = 1.57$) than the higher spatial exploration level ($M = 3.46$, $SD = 1.34$). However, we did not find a statistically significant main effect for the coins factor ($F[1, 27] = .842$, $p = .366$) and the spatial exploration × coins interaction effect ($F[1, 27] = .336$, $p = .566$).

5 Discussions

In our preliminary study, we aimed to explore player behavior and perceived satisfaction in an open-world game that emphasizes exploration as the main goal while also including a secondary task of collecting coins. Our results suggest lower mean spatial exploration values on LSEC and HSEC conditions (**RQ1**). This is an expected result due to the intrinsic motivation triggered by rewards in the game [4, 5]. This means players tended to change their exploration through the game level assets to seek as many coins as they could during the delimited playtime. Researchers have explored similar mechanics, such as rewards, as a potential reason to catch players' attention [5]. Wang et al. [26] found that older adults perceived in-game rewards, such as coins and power-ups, as more enjoyable and valuable in an exercise game. Unlike the age group comparison, our findings relate to the motivation of playing games and the types of rewards that enhance player enjoyment and exploration. Another factor contributing to our results could be our decision to place the coins only in the empty spots. This design choice may distract players from the environment and focus their attention on seeking rewards instead.

Based on spatial exploration measurements of the synthesized game levels, we observed different spatial exploration behaviors among participants (LSE and HSE). However, we found no significant difference between the mean spatial exploration values. Notably, there was a significant offset between the target mean spatial exploration for the LSE condition ($\rho_M = .25$). However, our participants' mean value ($M = .69$) was consistent with our previous study [1] in which we observed a similar offset (offset = .43 for LSE, compared to our offset = .44). Conversely, the offset for the HSE condition was smaller (offset = .02).

Regarding the GUESS survey results, we found no significant differences between conditions in most categories, except for GRAT (**RQ2**). Players reported higher motivation to continue playing at a low spatial exploration level than a higher one. Surprisingly, the level layout and game assets influenced player motivation more than the presence of coins. To interpret these results, we must consider what aspects of the game led to lower ratings in high spatial exploration conditions, particularly for the HSEC conditions, where the mean average was low ($M = 2.60$). Additionally, the small sample size in this preliminary study might have impacted these results, and the trend could differ with a larger population. This finding is supported by larger sample studies, such as the one we conducted with the same optimization method [1], where we did not find significant differences in any GUESS survey categories when comparing synthesized game levels. Similarly, Gómez-Maureira et al. [10] found no significant differences in GUESS ratings when exploring curiosity exploration patterns.

We identified several limitations in this preliminary study. Initially, the main goal of "You have 10 minutes to explore the level" may not give players a strong sense of purpose. To address this, we could incorporate narratives to immerse players in the environment and give a reason for the character to explore. Another limitation is the placement of in-game rewards. In this experiment,

Table 1: Detailed results of our study (significant results are bold).

	SEF		SCORE		ENJ		CRE		ENGR		GRAT	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
LSEC	52.63	5.79	81.43	8.24	3.43	1.11	5.22	.77	4.16	.90	4.76	2.05
HSEC	49.74	6.05	84.86	9.14	3.51	.77	4.24	1.21	3.13	1.00	2.60	1.14
LSE	69.87	5.93	65.86	14.02	4.00	.84	4.57	1.04	3.75	.82	4.50	1.06
HSE	73.65	5.71	70.86	20.59	3.00	.69	4.24	1.22	3.77	1.04	4.33	.91
Main Effect (Spatial Exploration)												
F		.040		.644		1.939		2.592		2.035		**5.109**
p		.843		.430		.177		.120		.167		**.033**
Main Effect (Coins)												
F		**85.874**		**7.932**		.008		.648		.106		2.045
p		**.001**		**.010**		.931		.429		.748		.166
Interaction Effect (Spatial Exploration × Coins)												
F		2.248		.022		2.735		.648		2.181		3.753
p		.147		.882		.111		.429		.153		.065
Spatial Exploration $df = 1$, Coins $df = 1$, Interaction $df = 1$, and Error $df = 27$												

we used 20 coins, which we noted as sufficient to cover a significant percentage of empty cells. However, various approaches, such as interest and motivation, could be better explored to enhance player behavior. Furthermore, the type of reward used, such as coins in this study, can vary in its influence on spatial exploration behavior. For instance, using a treasure chest (e.g., loot box) instead of a coin could affect players differently due to increased uncertainty [6]. Assuming the chest drops random rewards, this would likely heighten curiosity. Additionally, measuring players' motivation profiles before gameplay could provide a better understanding of the types of players participating in our study. This preliminary study allowed us to analyze how the participants engaged with the designed game conditions and assess their performance. Regarding the unexpected findings, larger samples, determined by power analysis, will help us understand why this occurred and how it may affect potential spatial exploration targets. Additionally, other data collection methods, such as qualitative data through interviews, could provide more insights into how the game level and the presence of coins could impact players' spatial exploration behavior.

6 Conclusions and Future Work

In this paper, we conducted a pilot study to explore the effects of including a secondary task (i.e., collecting coins) on players' spatial exploration behavior. Our preliminary results suggest that the presence of coins inversely affects players' interest in the defined game level assets, resulting in significantly lower spatial exploration in conditions that included coins. The defined spatial score also indicates significantly fewer visited occupied cells in these conditions. Furthermore, players reported higher motivation when playing levels with low spatial exploration (LSE) compared to high spatial exploration (HSE). These results were unexpected, as we anticipated that a higher spatial exploration target would increase user satisfaction due to the game level assets. The influence between the placed elements and the effective layout warrants further exploration. Considering the highlighted limitations, we plan to revise our methodology for our future large-scale study. We will conduct a more extensive analysis comparing gender, gamer profiles, and self-perceived curiosity. Additionally, we will consider examining a different secondary task, as the sense of achievement and reward provided by coin collection may differ from less "rewarding" tasks. A larger-scale study would confirm the obtained significance and provide a detailed explanation of player gameplay behaviors.

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