Guiding Players through Structural Composition Patterns in 3D Adventure Games

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ABSTRACT

How to guide players towards a more interesting experience without taking away player agency is a key challenge in game design. In this paper, we propose our approach for guiding players' spatial navigation in 3D adventure games. Based on close analysis of popular adventure games, we propose a set of five 3D *structural composition patterns* to guide players through level design. To evaluate their effectiveness, we conducted a user study using two versions of a grey-box environment embodying these patterns in varied ways. Our results show that the Shifting Elevation pattern and the Directional Line pattern have a strong impact on influencing player's movement choices.

1. INTRODUCTION

A key challenge in computer games, especially the narrative-centric ones, is the well-known "narrative paradox" — the conflict between designers' authorial control to maintain certain qualities of the experience and players' agency to explore and interact with the world as they wish [2]. Generally speaking, the more freedom a player has to influence the game world, the stronger her sense of agency. However, it also makes it harder for the game designers to control the quality of the outcome story, such as its coherence and dramatic arc. This conflict between delivering quality and agency to players is a core challenge to many genres of computer games.

To resolve the narrative paradox, recent research in the game artificial intelligence (AI) community has been conducted using drama managers (DM) and the more generalized experience managers (EM). These systems are designed to control the overall trajectory of the stories, or player experience in general. Based on player interaction, DMs dynamically modify the upcoming narrative events so that the overall story will satisfy a pre-determined set of quality requirements. At the same time, they still provide player agency to participate and influence the story [12, 14]. For example, the interactive drama system *Façade* uses DM to dynamically selects the next narrative beats based on player interaction while ensuring the resulting story will follow the Aristotelian arc.

Complementary to the AI approach, designers of computer games and other location-based entertainment have long developed techniques to "nudge" players along designer-preferred paths while still leaving other options open. As Richard Lemarchand, the lead game designer of the *Uncharted* series puts it, a well-designed game should "guide our audience's attention to things that enrich their experience, and away from things that don't" [11].

In the past, games relied on obvious visual cues (e.g., a flashing arrow or a weapons targeting device) or direct audio instruction to direct players towards certain goal areas. Recent games have embedded these cues more seamlessly in the level design. For example, Thatgamecompany's game *Journey* successfully uses visual cues (e.g., landscape, lighting and viewpoint) to guide the player in an open world without using explicit instructions. When the player is first dropped into the environment of endless sand dunes without any verbal direction, the camera pans around and finally stops when pointing directly at the highest ridge nearby. The dominant shape of the hill in the view communicates to the player of her immediate goal. Once she reaches the top of the ridge, the player is then presented with a significantly taller mountain in the distance, the final goal of the whole game. As shown in these examples, the landscape in *Journey* is designed explicitly to draw players' attention and direct them towards areas where the designers intend them to go. At the same time, the players still have some freedom to venture out and explore limited areas.

We aim to develop a framework of game design patterns to guide players towards preferred paths. We chose to start with 3D adventure games, a genre where navigation and storytelling are essential to the gameplay. In particular, we focus on *structural composition patterns* such as the shape and size of structures in relation to their surrounding landscape. Our goal is to start formalizing these patterns in a principled way for supporting level design decisions especially in the grey-boxing phase [15].

Our long-term goal is to integrate these level design patterns with game AI for procedurally generating and adjusting levels, so that players may be directed to different areas depending on how they play. Recent EM systems have started to explore the connection between narrative and game level design. For example, Sharma et. al.'s system [16] dynamically changes key game elements in the map so that the player can be better guided to go through the interactive

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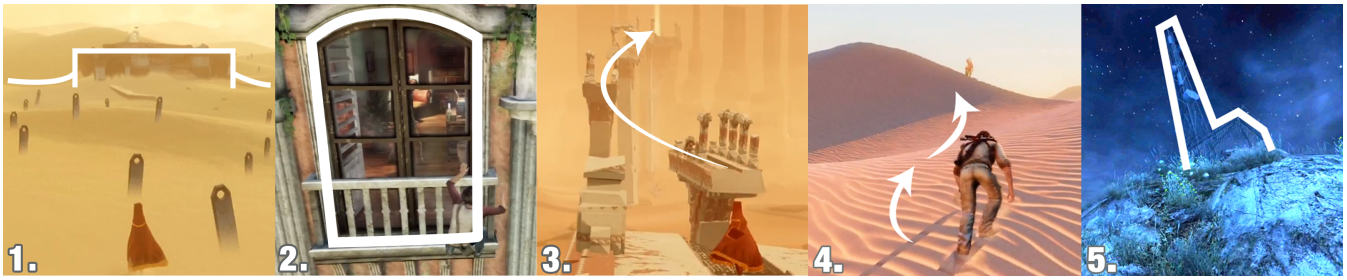

Figure 1: Selected scenes representing structural composition patterns.

fiction game. However, this takes place at the granularity of levels. For instance, an NPC character who reveals a crucial clue may be placed in the room next to where the player currently is. The system still is not capable of changing the game environment within a level so that the player can be guided to discover these key elements on their own. We believe that developing a more formalized system of level design patterns is the first step towards our long-term goal.

In this paper, we present our initial set of structural composition patterns to guide players. These patterns are developed by close analysis of popular 3D Adventure games (e.g., *Uncharted 3*, *Dear Esther*, and *Journey*) as well as insights from related fields such as theme park design. In order to evaluate the effectiveness of these patterns, we designed two variations of a grey-box environment containing these patterns at decision points and empirically tested their effect on players through a user study. Our preliminary findings show that some of our patterns, particularly the Shifting Elevation pattern and the Directional Line pattern have a strong impact on directing our participants. Other patterns are noticed and taken into account by some participants. We also encountered other influential factors such as players' handedness and the ordering of their previous choices.

The rest of the paper is organized as follows. We first present related work in traditional media and games. We then describe the five structural composition patterns in Section 3 . Next, we describe the design of our user study in Section 4 and report our findings in Section 5. Finally, we present our conclusions and future research directions.

2. RELATED WORK

The question of how to direct one's spatial navigation in order to create an aesthetic experience is much older than computer game design. In landscape design, for instance, there is a rich tradition of using landscape elements to guide the visitor's viewpoints to achieve certain psychological effects. In this section, we discuss related work in physical environment design and level design patterns in computer games.

2.1 Landscape and Theme Park Design

Directing visitors through the environment and guiding their attention to various focal points is an important part of landscape and architecture design [10]. For example, in Maya Lin's Vietnam Memorial Wall in Washington D.C. [20], the V-shaped wall directs the visitor to gradually descend into the ground, turn, and eventually walk upwards towards the vertical structure of the Washington Memorial in the distance.

Similar techniques are heavily used in theme park design. In the Disney parks, imagineers carefully structure physical environments so that guests, while moving from one place to another, can see and hear in new ways. These "environment storytelling" techniques [4] help to create an immersive narrative experience and essentially a place to play.

A frequently used technique at the Disney parks is *weaning points* [7]. Designed to attract guests' attention from a distance and lead them to its location, a weaning point is a vertical structure above the horizon line, visible from different parts of the park. An example is the Space Mountain at Disney World. Among the tallest structures in the whole park, it is visible from multiple areas and attracts visitors towards Tomorrowland, where it resides. Unlike the Cinderella Castle with straight main roads leading to it, most roads connecting Space Mountain are designed to curve around obstructions to make the journey more interesting. Along the winding paths, the visitors can see the weaning points in strategic locations, reminding them their main objective. Weaning points have already been used in game design. In his GDC talk [11], Richard Lemarchand mentioned that weaning point is a effective way to guide game player's attention in the *Uncharted* series.

2.2 Game Design Patterns

Following Christopher Alexander's influential notion of *patterns* in architecture design, game scholars and designers have been developing patten languages for games. For instance, the Game Ontology Project develops a hierarchical framework of structural concepts to analyze games [21]. Björk and Holopainen collected several hundred game design patterns and discussed their forms, consequences, and relations[3]. Others focus on specific genres and aspects of games such as RPGs [17] and level design for FPS games [9]. Similar to Alexander's approach, most of these frameworks are derived from the authors' close analysis of a large amount of games; some [21] explicitly use grounded theory [6] as their methodology. Our work uses a similar methodology to develop our patterns. In addition, we empirically test the patterns we build through a user study.

Despite the existing work on different game design patterns, how to construct levels to guide players is still not well understood. For example in Björk and Holopainen's immersion patterns, they describe that games require players' attention and as such can make players focus on gameplay to the extent that they feel immersed in the games [3]. Although they briefly discuss that one use of this pattern is spatial immersion, there is not sufficient information about specific effects of different composition patterns to understand what draws players' attention. Our work hence extends theirs by focusing on specific patterns that can be

directly used in game level design.

More closely related to our work, Milam and El Nasr [13] focus on level design patterns to guide players' moment-to-moment and goal-driven movement in 3D games. Their patterns, gathered through expert interview and game analysis, include Collection, Path Target, Pursue AI, Path Movement and Resistance, and Player is Vulnerable. Different from our work, their patterns focus on literal visual guidance. For example, they study how the path target pattern orients and directs the player's movement towards visible targets such as a targeting device, or how the path movement pattern can be with a path resistance patterns such as a locked door. By contrast, our work focuses on more subtle cues and leaves player with relatively more freedom to choose otherwise. We believe that the two approaches are complementary and could be combined in a future study for better results.

Finally, there has been several similar studies on effectiveness of certain level design techniques based on psychology techniques [1] and different types of player motivations [8]. In our work, we focus less on specific level design techniques, and more on more generalized patterns of level design.

3. STRUCTURAL COMPOSITION PATTERNS IN 3D ADVENTURE GAMES

In this paper, we focus on *structural composition* patterns such as shape, space, and form to guide players to certain areas of a level. As argued above, understanding such patterns can help to direct players to the areas desired by the game designers without reducing player agency and thus help to alleviate the Narrative Paradox. The following five structural composition patterns for 3D adventure games were derived from our close analysis of three widely played games of this genre: *Uncharted 3*, *Dear Esther*, and *Journey*. We chose these three titles mainly because of their focus on guiding player's navigation without explicitly telling them where to go. Although we believe that these patterns may work in combination with each other to create a stronger attention point, further studies are needed. These five principles are our departure point for possible means of influencing player's navigation. We acknowledge that there may be more principles for further study. Below, we will discuss how we tested these five principles and what we found in the study results.

Contrasting Shape Pattern: A structure whose overall shape is substantially different from that of its adjacent environments (e.g., organic vs. rigid). Through such contrast, designers can call attention to certain structures in the environment. This pattern concerns the figural quality of the shape and its relationship to the environmental boundary around the shape. For example, in a scene from *Journey* (Fig. 1.1), the massive angular structure draws player's attention through contrasting with its surroundings of the organic shape of sand dunes and small and scattered structures.

Framed Structure Pattern: A frame may occlude foreground information, directing player's attention to mid- or background structures. In its simple case, a framing device may enframe a view without occlusion to suggest the difference between the inside and the outside. This pattern guide players' attention by heightening the legibility of the subset view. For example, in *Uncharted 3* designers utilized windows and archways in the "Greatness from Small Beginnings" level (Fig. 1.2) to bring focus to specific path goals(e.g., stairs) and important narrative elements.

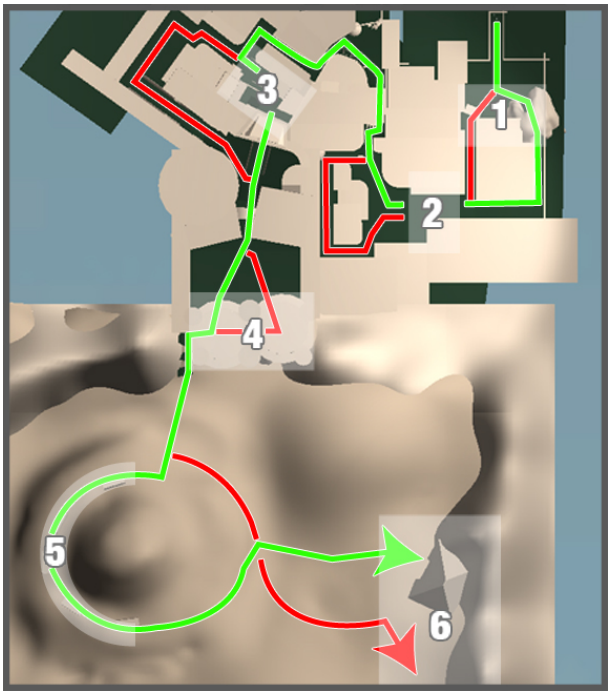

Figure 2: Layout of the grey-box level (Map A)

Directional Line Pattern: A series of repetitive lines and/or edges visually defines an actual or metaphoric pathway linking foreground, midground, and background through foreshortening. The pattern draws player's attention by defining an implied perspective view thought the diminishing size of repetitive patterning. For example, in Figure 1.3, the player is directed along a path from the repetitious placement of bridge-like structures, which lead to the end goal of "The Bridge" sequence in *Journey*.

Shifting Elevation Pattern: A spatial relationship between the current ground plane and line of sight. This pattern draws attention by manipulating the vertical distance between the ground plane in relation to foreground, midground and background elements below or above it. For ex-

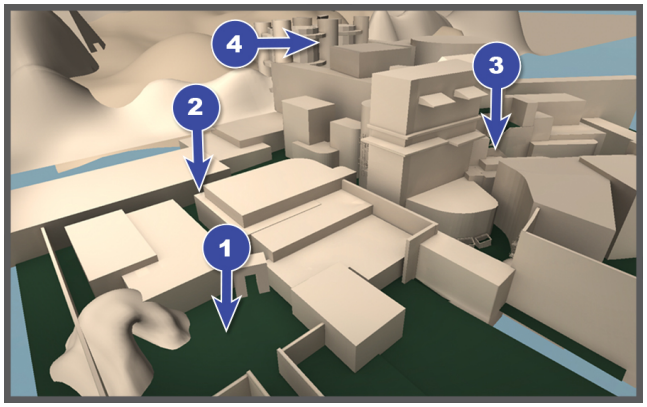

Figure 3: Bird's-eye view of the level (Map A)

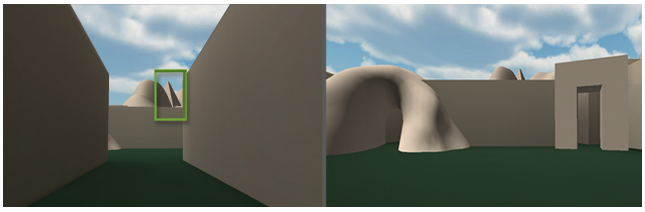

Figure 4: Left: weaning point visible from the level; right: organic vs. rigid structures in Zone 1

ample, in the "Mirage of the Desert" sequence of *Uncharted 3* (see Fig. 1.4), the designers shifted the elevation of the level in order to guide the player from one mirage to the next using elevated desert planes.

Structural Exaggeration Pattern: Exaggerated structures stand out from their surrounding and draw the player's attention towards them. Compared with the Contrasting Shape pattern, this one is not concerned with the characteristics of the shapes themselves (e.g., organic or rigid). Instead, it deals with the *altered scale* of structures. An exaggerated structure, usually enlarged, breaks the horizontal plane created when structures have a similar scale. This pattern thus directs player's attention to structures with substantial visual weight, position, balance and/or depth. For example, the player of *Dear Esther* is directed towards the phone tower (see Fig. 1.5), an element given prominence by being significantly taller than its surrounding and its placement as one of the furthest locations in the level. A weaning point is an instance of this pattern, usually with winding paths leading to it.

4. STUDY DESIGN

In order to empirically evaluate the effectiveness of our patterns to guide players, we designed and conducted a user study. We developed two variations of a 3D grey-box environment, each of which incorporates a different set of the above patterns. Following a widely-used level design method of grey-box testing [15], our test space is a grey rough environment without texture, lighting, and other smaller scale details. As our focus is in spatial composition (e.g., the scale and shape of structures and their relationship to one another), we use the grey-box technique to abstract out other visual elements such as texture, color, and lighting. Our hypothesis is that *each of our structural composition patterns will guide players to a designer-preferred area.*

Our testing grey-box environment is designed to resemble the layout and control scheme of common 3D adventure games such as *Dear Esther* where spatial exploration is the center of gameplay. Throughout the grey-box levels, we placed six zones. Each zone contains a decision point where the player has to choose from two mutually-exclusive options of paths (*options*). In Fig. 2, we indicate our preferred path as the designers with the green arrow, whereas the red arrow represents the alternative path. Each zone corresponds one of the above patterns, with the Structural Exaggeration pattern split into a standard one and a weaning point. Players start at the upper right conner of the map shown as Fig. 2.

To test the effect of the patterns, we designed two versions of the environment, Map A and Map B. Built on the A/B testing methodology, we designed two versions which are

Table 1: Zones, patterns in Map A & B, and the side which each preferred path is on

Zone	Pattern	Map A	Map B	Preferred
1	Contrasting Shape	✓	✓	Left
2	Framed Structure	✗	✓	Right
3	Elevation	✓	✗	Left
4	Exaggeration	✗	✓	Right
5	Directional Line	✓	✗	Right
6	Weaning Point	✓	✓	Left

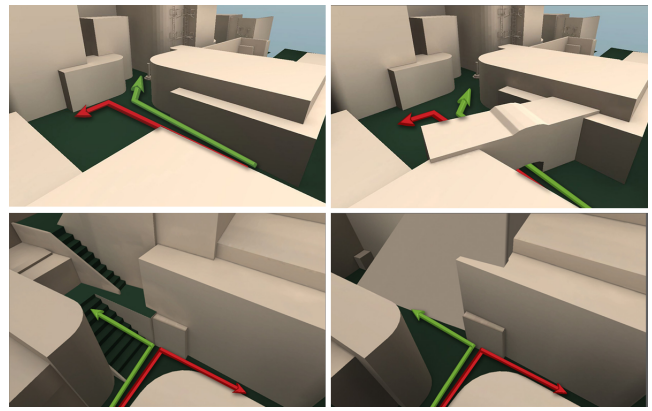

Figure 5: Top left/right: Zone 2 in Map A/B; bottom left/right: Zone 3 in Map A/B

identical except the options in the six zones. The existence of a pattern, with the exception of Zone 1 and 6 (details below), is randomly assigned to one and only one of the two maps (Table 1). We used between-subjects variability. In other words, no participants played more than one map.

It is crucial for our study that each option within a zone is similarly represented so that the only difference is the structures themselves. For example, if a player sees one option before the other, it may introduce an ordering effect. To control these variables, the testing environment constrains the player's viewing frustum as she approached the zones. Unless otherwise specified, both options become visible at the same time. To counter-balance the resulting constraints a player may feel, we created what we call *visual breathing points*, that is small areas in between zones where the player can explore and look around more freely. From the study, we received no negative feedback about this setup. Below are details about each zone:

1. **Contrasting Shapes**: Zone 1 includes the options of an organic-shaped and a rigid-shaped entrance structure in a mostly rigid-shaped environment (Fig 4, right). The former resembles a cave entrance in the nature, whereas the latter looks like a doorway in a modern building. This zone is identical in Map A and Map B (i.e., the Contrasting Shapes pattern is present in both maps). The two entrances lead to two separate alleys, which meet at the open area before Zone 2.

2. **Framed Structure**: Zone 2 tests whether a framed structure can guide the player towards a specific goal upon exit. In Map B, the player goes through an archway that directly points to the pathway on the right (Fig. 5, top row.) The frame of the archway directs the

player's viewpoints straight at the right path (our preferred path) while occluding the left pathway. Upon exiting the archway, the player reaches a small open area where both pathways can be seen before she has to decide which direction to turn. To add to the visual interestingness of the area, we added a pillar and fire escapes along the walls in the right path. Zone 2 in Map A is identical to that in Map B, except it does not contain the archway.

3. **Shifting Elevation**: Zone 3 tests the effect, if any, of using a shift in elevation to direct players to a preferred path. Players in Map A are presented with an elevated set of stairs to the left (preferred) and a flat pathway on the right. Map B contains the same two options of turning left or right, but displays no elevation shifts from where the player is currently (Fig. 5, bottom). Only after the player makes the decision of turning left in Map B will she find a ramp going up.

4. **Structural Exaggeration**: Zone 4 tests the impact of exaggerated structures on player's navigation. Map A contains two buildings of similar scale, whereas Map B contains a significantly taller building. The player can choose to enter either building, both of which will lead to the same open area (Fig. 6, Top). The path with the taller building is preferred.

5. **Directional Line**: In Zone 5, the player has the option of going left or right around the elevated sand dune, after the two tall structures (Zone 6) to their left become visible. In Map A, as shown in Fig. 6 bottom left, a series of repeated structures form a curved line on the righthand of the dune (preferred). There is no such structure in Map B. Our intention is to guide player's attention to the right through the directional line in Map A.

6. **Weaning Point** - Zone 6 tests the effect of the weaning point. It contains two distinct vertical structures — a pyramid and a tower of similar scales and shapes (Fig. 6 bottom right). The preferred pyramid structure, a weaning point, is visible from afar before a player reaches Zone 1 in the beginning of the level. The tower is only visible when the player reaches Zone 6. The setup in Map A and B is identical. When the player enters either structures, the session ends.

Our target demographic is individuals between the ages of 18-35 who have played 3D games before and are familiar with a standard 3D navigation interface. Limited information about the study was provided to the participants in the beginning of the study. Participants were only briefed with the following: "This is a navigation experiment. You will be presented with path options throughout the level. There is no right or wrong way to go. Please choose what feels most natural to you and once you choose that direction please continue to move forward. There will be a post interview process following your play through."

After each test session, we interviewed each participant about their decision-making process. While reviewing their play-through videos together, we asked their reason, if any, for making their specific choices.

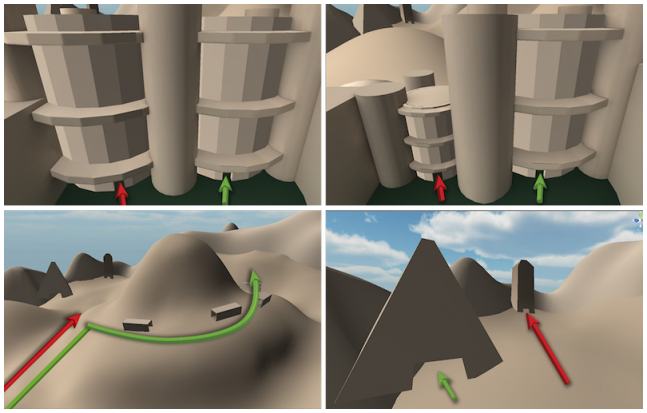

Figure 6: Top left/right: Zone 4 in Map A/B; bottom left/right: Zone 5 in Map A/B

Table 2: Percentage of participants who took the preferred/non-preferred path & percentage increase (zones with patterns are in bold)

Zone	1	2	3	4	5	6
MapA	**55/45**	55/45	**90/10**	70/30	**55/45**	**55/45**
MapB	**35/65**	**60/40**	25/75	**70/30**	15/80	**35/60**
Total	**45/55**					**45/52.5**
Incr.		9	260	0	72.7	

5. RESULTS

In our study, we recruited 40 participants. Their age range is 18 - 48 with the average age of 21. They play an average of 2-5 hours of computer games per week. Each participant was randomly assigned to either Map A or Map B. They only go through the environment once for a maximum of 15 minutes before the system times out automatically.

One researcher from the study was present at the testing location to observe each participant. He took notes but did not make any comments to influence the playthrough. After a participant finished, the researcher interviewed him/her individually to discuss his/her decision-making process. We then used both the quantitative data from gameplay and qualitative data from post-test interviews for our analysis.

5.1 Quantitative Analysis

Table 2 summarizes the results of the participants' navigation. For each zone and each map, the table lists the percentage of participants who took our preferred path versus those who did not. The numbers are in a bold font when they are from options corresponding to one of our patterns. In zones where the settings between Map A and B are identical (i.e., Zone 1 and 6), we aggregated the total numbers between the two maps. In the rest of the zones, the table lists the percentage increase of participants who took the preferred path from a map *without* the corresponding pattern to the one *with*. One participant assigned to Map B did not complete the level because he was lost in the environment and started backtracking until the experiment timed out after 15 minutes.

Overall, except the patterns of Shifting Elevation (Zone 3) and Directional Lines (Zone 5), we do not see a significant statistical difference between how the participants navigated the environment with and without the patterns. However, as

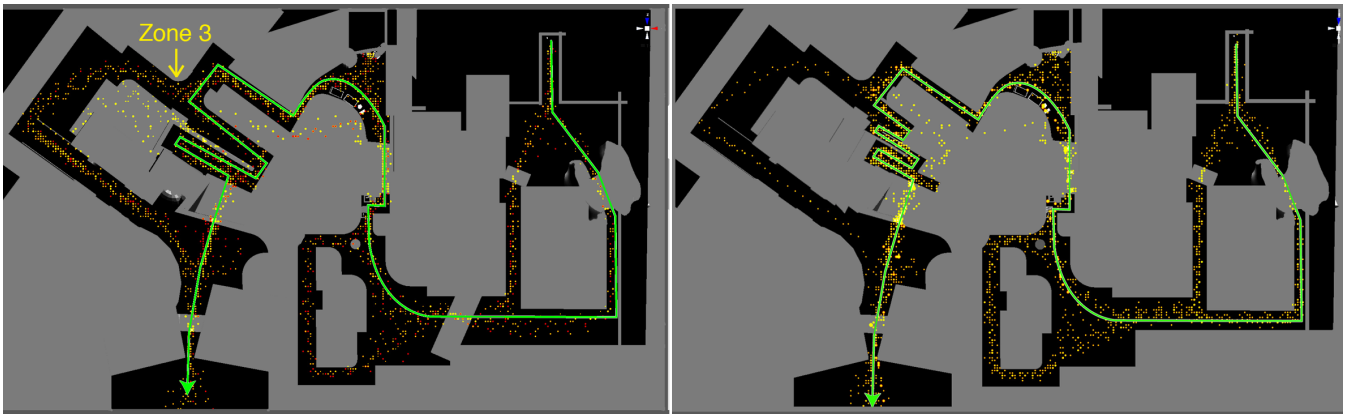

Figure 7: Heatmaps of Map A (left) & map B (right) in Zones 1-4

discussed in more details below, the qualitative data does indicate that the other patterns influenced some participants' decision-making process.

More specifically, in Zone 1 the organic entrance with *Contrasting Shape*, aggregating two maps, attracted 45% of the participants; 55% went through the alternative structure. As we will discuss in Section 5.2, the results may be influenced by an unintended level design choice we made.

In Zone 2, 60% of the participants in Map B with the framed structure chose to go through our preferred path, a 9% increase from the number in Map A where the Framed Structure pattern is not used.

We observed the strongest statistical difference in Zone 3 where we test the Shifting Elevation pattern. In Map B where the pattern is not used, 25% of the participants chose the preferred path. In comparison, when the pattern is used in Map A, 90% of participants did the same, representing a 260% increase.

In Zone 4, there is no statistical difference in terms of which path the participants chose regardless of whether the exaggerated shape is used.

The directional lines pattern in Zone 5 also produced significant changes in participants' navigation choices. After seeing the two tall structures of the final goals, 15% of the participants in Map B chose to take the detour (preferred path) without the directional lines pattern, whereas 55% did so in Map A with the pattern. There is a 72.7% of increase.

In Zone 6, a combined total of 45% of participants chose to navigate towards the tower structure, and 52.5% chose the preferred pyramid, a weaning point.

We aggregated all participants' navigation in a heat map. Due to space limit, we only show the data from the first 4 zones (Fig. 7). The heat maps show that the participants collectively explored almost everywhere in the map. This is partly due to our decision to allow back tracking, as supported in most commercial 3D adventure games. The only easily visible trend difference in the heat maps is the patterns of navigation in Zone 3 in the upper-left corner.

5.2 Post-test Interview Analysis

A post-test interview was held immediately following each participant's playthrough. A researcher reviewed the playthrough video with the participant, and asked her the reason, if any, why she made these particular choices. Our analysis of these interview provided more detailed accounts and contexts to the quantitative results above.

A significant finding is that in Zone 1, among the participants who went through the preferred path, most of them made a conscious decision of doing so because of the contrasting shape pattern. Specifically, in Map A, all 11 out of 11 participants who chose the preferred path mentioned organic shape in their reflection. In Map B, 5 out of 7 participants did the same. It was reported that they found the organic-shaped entrance look more interesting than the alternative structure. User 007 and 010 of Map A used the terms "exploration" and "adventurous" respectively to describe the organic-shaped entrance. We also discovered that the things behind the entrances played an unintended role. Some participants who chose the rigid entrance reported that their choice was due to the fact that the things *behind* the rigid doorway seemed more interesting. In other words, the doorways also played the role of the Framed Structure pattern. The unintended consequence of this overlooked design is that some participants were not merely choosing between the characteristics of the shapes themselves, but other objects called attention to *by* these shapes. In addition, User 004 of Map B discussed that he is right-handed and felt that he mainly gravitates towards the right when making his choices. The handedness is a recurring issue across zones. We will further discuss it below in Section 5.3.

In Zone 2, no participants explicitly stated that the framed structure guided them towards the preferred path to the right. The biggest influence based on the interview was the pillar and fire escapes to the right. User 008 of Map B mentioned that upon exiting the frame structure, he initially gravitated towards the left but changed his decision as soon as he saw the above-mentioned structures to his right. Similarly, User 006 in map A mentioned that the fire escapes caught his attention and was the significant reason for his decision to turn right. In map A, user 008 explored the left side because it seemed "smaller in size" and felt that the ladders made the right side feel more expansive. This was unintended as we placed the objects there only to add some visual complexity.

Zone 3 displayed a significant statistical differences between the two maps. The post-test interviews confirmed the difference is due to the change of elevation in Map A. In map B (without shifting elevation), user 011 talked about how he did not go left because nothing seemed to influence

his decision to go in that direction. By contrast, most participants in map A explicitly mentioned the stairs drew their attention and influenced their decision. For example, User 009 specifically mentioned that he saw the stairs and chose to go there because he usually liked to go higher when playing. Similarly, User 002 felt that the stairs would lead him to a place where he could see everything. User 012 also specifically mentioned that the stairs drew interest compared to his other option, which had a similar floor plane he was presently on. User 013 mentions that the right hand side would most likely be more flat and the left would allow him to go upwards. Both quantitative and qualitative results suggest that the change of elevation has a strong influence to guide players towards a certain direction.

The exaggerated shapes in Zone 4 displayed no influence on our participants' navigation. In the interview, more than 57% of the participants who went to the preferred structure in Map B mentioned that they chose the preferred exaggerated building because of its exaggerated scale. In map A where both buildings are of equal size, User 007 mentioned that due to their same size he went with the closer option. User 016 specifically mentioned that he thought they were both the same size and it was a coin flip. When the researcher further asked him whether anything would have influenced his decision, he responded that he would have gone to a much taller building over a smaller one. These comments were made without the researcher introduce any concepts related to scale. Furthermore, several players mentioned that their choices were influenced by the directions they chose previously. For example, some participants stated that they decided to go one direction (e.g., left) because they had been constantly taking the opposition direction until this point and decided to make a change.

As shown above, the repeated line structures in Zone 5 also displayed a strong impact on the participants' navigational pattern. Our interviews confirmed that most of the participants see the two Zone 6 structures in the distance as points of interest and wanted to go there. Participants in Map A (with the Directional Line pattern) specifically mentioned that their decisions were motivated by the curiosity of what may be placed in the repeated structures. User 13 in Map A explained that he likes to follow things in the distance and found those tunnels interesting. User 015 brought up that normally the user is rewarded if they spend the time to explore, as opposed to go towards the goal immediately. Similarly, User 006 discussed that the ring created from the placement of the boxes was very intriguing and (correctly) felt it would eventually lead him back to the tower he saw to the left. In Map B where there are no lined structures, most of the 80% who chose the non-preferred path directly towards the towers said that their main reason was because nothing drew their attention to the right; as soon as they saw the tower structures in the distance they went in that direction. Two participants who did turn right (preferred) said that they did so because they were concerned they would miss something otherwise.

Finally, more participants chose to go to the tower structure as opposed to the preferred pyramid structure in Zone 6. Among those who chose the pyramid structure, 3 users from Map A and 4 from Map B responded that they felt it was a more interesting shape. In comparison, among those who chose the tower structure, 1 user from Map A and 7 from Map B said that they did so because it was the furthest location from them. When asked if they remembered seeing any of those structures from the beginning of the game, no one recalled they did.

5.3 Discussions

As mentioned above, interviews with participants suggest that their particular handedness impacts their navigation. Certain participants stated that they usually chose to go right when making directional decisions. Two participants specifically notated that they normally follow the "wall follower" rule, a strategy for traversing mazes. Revealingly, a left-handed participant referred to it as the left hand on the wall rule, whereas a right-handed participant called it the right hand rule. Another participant mentioned he followed his military training and routinely scanned the environment in the order of left to right.

As we did not fully anticipate the impact of the handedness of the participant, it was not accounted for in our original design and data collection. Fortunately, we distributed the level design elements embodying different patterns evenly on two sides (Table 1, under "preferred"). Once we realized that it is an important factor, the researcher informally asked the participants whether they were predominately right- or left- handed. The partial results show that the right-handed participants outweighed the left-handed ones. However, our current study is not sufficient to completely mitigate the effect of the handedness. In our future work, we plan to randomly switch the side where the preferred-path with the patterns is placed. This finding can be useful for game designers. Recognizing that, under comparable conditions, many players inadvertently choose to go right can help designers to construct their levels and direct player attention more effectively.

Another useful observation is the impact of the order effect, as some participants mentioned their decision to switch sides after taking the same side for too long. It is an area that needs further study. However, it is our untested belief that the impact of appropriate structural elements to guide players is stronger than that of the ordering effect.

This study revealed several limitation on our design of the environment. For example, Zone 1 did not separate the structures being tested from the ones behind them. Zone 2 has asymmetric points of interests (pillar and fire escapes) on one side but not the other. In a future study, we will reduce these distracting factors. In Zone 6, we plan to make the weaning point of the pyramid visible from more places throughout the level before presenting it as the end.

6. CONCLUSION & FUTURE WORK

In this paper we discussed and evaluated our approach for guiding players' navigation through structural composition patterns in 3D adventure games. Through close analysis of popular 3D adventure games, we proposed five structural composition patterns. Next, we designed two versions of a grey-box environment embodying these patterns and conducted a user study to test the effectiveness of our patterns.

Through analyzing the quantitative and qualitative data we collected in the study, we found that in general structural composition patterns we placed have impacted some player's navigational direction. All five of our patterns were explicitly echoed in some participants' accounts for their decision-making process. Among them, the Shifting Elevation pattern and the Directional Line pattern showed a significant

impact on guiding players towards our intended paths.

This study provides valuable information for our future work. First, we plan to run a larger study after revising the test environment based on our observations. We plan to randomly swap two alternative choices in the same zone in order to better account for the handedness effect. Design elements that we overlooked will be corrected. We also plan to investigate combining our work with other patterns such as Milam and El Nasr's work [13] for stronger results on directing players.

Second, we are interested in incorporating our patterns into game AI techniques such as experience management. As mentioned above, they can incorporated into story-driven map generation [19], as a component of EM. The patterns can also be useful for procedural content generation research which uses formal approaches to level generation.

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