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Curiosity and Wayfinding

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Abstract

Navigation and exploration of virtual environments is often referred to as an important feature of video games. As such it is worthwhile to create navigable environments that also immerse players in an imaginative world, without cluttering the visuals with forceful aids. With this study we aim to find out if certain graphical elements or arrangements of space can affect the wayfinding choices of players, and thereby contribute with knowledge of how to create well-crafted environments. We created a 3D-environment with crossroads containing paths with opposing graphical elements or arrangements of space. Participants played through this environment and with a mixed methods approach we gathered quantitative data on their choices and qualitative data from an open-ended survey question. The results showed that certain paths were more popular over their counterpart contrasting paths.

Video games, navigation, graphics, game design

Sammanfattning

Navigering och utforskning av virtuella miljöer anses ofta vara ett viktigt inslag i videospel. Därför är det värdefullt att skapa navigerbara miljöer som också kan absorbera spelare i en fantasifull värld, utan att belamra det visuella med krystade hjälpmedel. Med denna studie vill vi ta reda på om vissa grafiska element eller rumsliga arrangemang kan påverka spelares vägval, och på så vis bidra med kunskap om hur en kan skapa välanpassade miljöer. Vi skapade en 3D-miljö med vägskäl innehållandes vägar med motsatta grafiska element eller rumsliga arrangemang. Deltagare spelade igenom denna miljö och med ett *mixed methods*-tillvägagångssätt samlade vi in kvantitativ data om spelarnas val, samt kvalitativ data från en öppen enkätfråga. Resultaten visade att vägar tillskrivna vissa grafiska element eller arrangemang var mer populära än dess motsatsvägar som innehöll kontrasterande element eller arrangemang.

Videospel, farbarhet, grafik, videospeldesign

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1 Introduction

1.1 Background

Exploration of the built environment in game worlds has been an entertaining factor of games since the dawn of the medium. While not much to look at in terms of realism, even early games like *Pong* (Atari, 1972) present a virtual space that the player must perceive and become acquainted with, to be able to understand how to play the game. With higher performance come better graphics quality and greater potential for photo-realism. This makes it possible to create more complex and larger environments that can, not only more successfully replicate the real world and the beauties that lie in it, but also give way to aesthetically pleasing make believe environments. With expanding possibilities for creating complex environments, the role of exploration can become bigger.

The exploration of virtual space in games can be said to operate under the broader term of *navigation.* Darken and Peterson (2001) define navigation as a combination of the acts of *motion* and *wayfinding.* Motion is simply the physical movement of the agent, while wayfinding is the cognitive process involved in navigation - the agent's reasoning and tactical decision making when navigating - which will be the focus of this study. Darken and Peterson do however stress that motion and wayfinding are tightly intertwined and do not operate separately. An agent navigating a space will perceive an environment while moving, and process the information as it presents itself gradually through the agent's motion.

Flynn (2003) argues that navigation can be the carrier of cultural meaning and a defining feature of games, claiming that too much focus lies on narrative and ludus (play). Flynn means that by moving through computer space, you are actively "painting the picture" that is the game world. This gives the player agency in an imaginary world, enabling "the pleasure of aesthetic interaction". If navigation, and thereby the exploration of virtual space, can come to take a bigger role in games, then the aesthetic interaction (that Flynn argues navigation

can contribute to) has potential to become more involving, especially as graphics develop.

It is however not a novel idea that exploration is an important part of games. When discussing the pleasures that games provide, Salen and Zimmerman (2004, pp. 334-335) mention exploration as a key element. They account for game designer Marc LeBlanc's typology of pleasure; pleasures that players can experience from games. One of these categories is *discovery*, which is the result of exploration. Exploration and discovery are however also intertwined with the category of pleasure that LeBlanc refers to as *sensation,* which entails pleasure from the games' visuals among other things. This is because while exploring an environment, the player is not only navigating through space, but also perceiving the surroundings. Salen and Zimmerman also list categories of pleasure from psychologist Michael J. Apter's essay *A Structural-Phenomenology of Play,* where *exploration* is one of them. Also here the categories can overlap, and the category Apter refers to as *Exposure to Arousing Stimulation,* will often be closely related to exploration. This reflects how Darken and Peterson (2001) connect motion and wayfinding, and Flynn's (2003) view of navigation as a way to interact with the games aesthetics.

1.2 Related Research

As mentioned earlier, this paper is interested in wayfinding, the cognitive process behind navigation. There are however different modes of wayfinding, and not all of them are of interest for this study. Darken and Sibert (1996) divide wayfinding into three categories: a *naïve* search is when the navigator doesn't have prior knowledge of the target location, a *primed* search is when the navigator knows the target location, and *exploration* occurs when there is no target.

Darken and Sibert (1996) studied how people's wayfinding abilities in the real world can help construct tools for the improvement of wayfinding in virtual environments, but the focus lied on searching tasks that only consisted of naïve and primed searches. Bidwell et al. (2007) stress the importance of exploration in games, with much weight on natural landscapes and wilderness, pointing out

the psychological and restorative effects such environments can have. They also claim that much focus lies on narratology and gameplay when designing game worlds. The goal of their study was to find a wayfinding device in games that doesn't require the addition of blatant architecture and abstract visual tools, so as to not limit immersion but still support fluid navigation, with naïve searches carried out in a 3D natural landscape. Moreover, Darken and Peterson (2001) compile a list of design principles to aid in the creation of navigable environments, based on architectural principles, but here too the concern is only primed and naïve searches, and the performance of the agent.

While previous studies have looked at questions of navigation and wayfinding in games, they often overlook the exploratory mode of wayfinding. It is often the case that naïve and primed searches are the interest of studies, because developing navigable spaces and devices for finding one's way in virtual environments are important for creating games that won't frustrate the player, and disorientation is seen as a negative side-effect of badly planned environments.

1.3 **Purpose of study**

Part of the aim for game development and graphics is to create games that, not only have interesting and immersive exploratory elements, but also enticing graphics that support exploration. If too many non-environmental visual aids can have the negative effect of cluttering the image and undermining immersion, then it is worthwhile to have ways of appealing to players underlying habits when exploring. With this study we aim to gain and contribute to knowledge about the underlying cognitive process of wayfinding.

What mentioned previous studies show is that the organization of space and tools can help make game worlds more navigable and make it easier to perform searches. They are however only concerned with *navigation performance*. With this paper we aim to study not how well players can find something, or how easily players gain spatial understanding of an environment, but rather if and how the organization of space - and other graphical elements - can affect the player's decision making when wayfinding. Additionally, we test two modes of

wayfinding: exploration and naïve search – thereby testing if this has bearing on the choices, or if the graphical aspects affect players independently.

1.4 Research Question

Can graphical elements affect the route which a player takes while exploring an unknown 3D environment?

1.5 Essay structure

In the **Theory** chapter, we account for the theoretical framework from which we have created the test. This includes art theory of color and shape, and theories from architecture.

In the following chapter we account for our **Method**, where we explain how we constructed the test, how we applied our theoretical framework, and how participants were recruited and how they performed the test.

Then we reveal the **Quantitative results** that have been recorded, which show the frequencies of path choices.

This is followed by our **Qualitative results**, which are comprised of answers that participants have left in a survey.

In the **Mixed analysis** chapter, we suppose possible explanations to our quantitative results by using the qualitative results; applying theory and our own reflections.

In the following **Discussion** we discuss possible problems with our results, and in what ways the study could have been executed differently.

We then present our **Conclusions** and suggest possible future studies.

2 Theory

Since exploration, as mentioned before, also has to do with the visual sensation that game graphics present, we aim not only to study the effect of organization of space, but amend this by also looking at how different graphical elements such as color and form can affect a player's exploratory wayfinding.

We base this on the idea that shapes and colors have different connotations. Chris Solarski (2012) accounts for the psychology of shapes. He asserts that round and circular shapes carry associations of innocence, youth and femininity, among others; square shapes carry associations of maturity, stability and balance, among others; and triangular shapes carry associations of aggression, force and masculinity, among others. This can be seen practiced throughout art historically, and is frequently used in games today. What this usually entails is that protagonists in games that are designed to look good and friendly often are round in their shape, while antagonists who are supposed to look evil are often angular in their shape, with sharp details. This can also be seen in environments, where safe, friendly places are often round in shape, while dangerous and evil places have dominantly angular shapes.

An example of this that Solarski (2012, 2013) presents is the protagonist *Mario* (Nintendo, 1981), who is depicted as good and friendly. In the modern iterations of Mario's character design, one can clearly see the circular shapes. An opposite of this can be seen in the antagonist Bowser, who is depicted as evil and dangerous. Although Bowser does have generally round shape to his body, to fit the style of the Mario universe, he has pointy details in the form of sharp spikes on his back and sharp horns and claws.

Solarski (2013) describes an experimental game he made to test how players reacted to environments of different shapes. In this game there are two levels, the first one attributed with round fluffy shapes, while the other with sharp angular shapes. The "trick" is that both levels are structurally identical apart from these visual features. He tested this with experienced gamers and inexperienced non-gamers and found that non-gamers were strongly affected by the spiky appearance and tried avoiding it as much as possible. Gamers on the

other hand often tested the rules of the game to see if the spikes hurt you, which they did not, and were thus less emotionally involved.

As mentioned, colors also have different connotations, one being color temperature. Colors in the red/orange spectrum are perceived as warm, while blue colors are perceived as cool. The temperature of colors can evoke different associations when used in different ways. While in some situations a strongly saturated warm color might evoke associations of a dangerous fire, it may in another situation be perceived as safe, homely warmth.

The field of architecture, unsurprisingly, also offers observations and views on the design of space; we cite two sources for strategies we use:

Alexander, Ishikawa and Silverstein (1977) for instance claim in their 'pattern language' that people are phototropic and will follow and orient themselves toward light (pp. 645-646) and that if light sources do not create a flow toward points of importance or if there is uniform illumination (p. 1160) they will feel disoriented. Some other points are made about warm and cool lighting (p. 1153) and the shapes of interior walls and ceilings, referring to slightly intruding angles and shapes as uncomfortable (pp. 883-888). They describe long corridors as generally unpleasant (p. 635) and came to the conclusion that there is a breaking point at 50 feet beyond which a corridor is considered 'long' in a study they conducted. Also, they postulate that climbing high places to survey one's surroundings seems to be a fundamental human instinct (p. 316).

Simon Unwin (1997) talks about how interplay between lines of sight and lines of passage can create a sense of mystery in the experience of architecture, with variation in congruence being the example (pp. 102-105), for instance how a path with a wall on its inside curve obscures its goal. He briefly describes how doorways of different sizes influence relations between visitor and occupant (p. 107); a large doorway reducing the status of the visitor while increasing the status of the occupant, a small doorway doing the opposite, while a human-sized door putting them at equal status. He describes the architectural element or strategy of parallel walls' focusing power when lines of passage converge with lines of perspective, creating a focal point and fixates free movement (pp. 139-147). His chapter on 'Transition, Hierarchy, Heart' (pp. 157-161) suggests that

transitional spaces are fundamental in the experience of architecture, suggesting that they help bring a change of tone and context. This is also related to a point on arcades by Alexander, Ishikawa and Silverstein (1977, p. 581). From this, we interpret that sudden change in space of different feel and purpose may be jarring without transitional intermediary spaces.

3 Methods

In this study, participants were invited to navigate a constructed digital 3-dimensional environment – a 'game'. Participants' wayfinding choices were recorded in a database together with their own optional qualitative descriptions of why they believed they made certain choices. Each choice in the environment is a crossroads with paths of contrasting appearance, for example one warmly lit path contrasted by a coolly lit path. Each crossroads is considered a separate test.

With a mixed methods approach, this study will look at how different organizations of space, forms and colors affect the choices players make when exploring an environment, by presenting subjects with choices in a 3D environment. Quantitatively, we will try to glean statistical results from participants' choices, to see if certain elements attract more than others, followed by questions (see appendix) in a qualitative approach, to try to find explanations that support the findings.

While the quantitative data is able to show general results on players' choices, the qualitative data can provide explanations as to how and why, which is the reason for the mixed methods approach; to reach a more complete answer to the research question (Creswell, 2014, p. 4).

3.1 **Game**

A short 'game' (see appendix for availability) was created in the game engine *Unity* (Unity Technologies, 2013), which consisted of a single level, played in first person view.

The level is built up of five chunks that differ in appearance. Each chunk contains a crossroads with two paths that present a choice to the player and which, upon entering one of these paths, leads the player to yet another new chunk with a new crossroads. The different chunks differ in the graphical content and design of the two paths. The two paths in each of the chunks have been formed as opposites, either within a certain graphical aspect or as opposing

architectural features. For example; in one chamber the player is presented with one path that is lit with a warm color, while the other path is lit with a cool color.

Additionally, the chunks contain corridors, chambers and yards all with different lighting and decor to break things up. The reason for this is that the 'game' should not be too blatant in its nature as a test, to make the participant, at least for a while, feel like she is playing a game like any other and make choices as though that were the case. In addition, these spaces in between crossroads, supported by Unwin's (1997) "Transition, Hierarchy, Heart" help separate and focus on each crossroads as an individual test by layering and elongating the experience. We took some effort in not letting these aspects intrude on the integrity of the test though, for example we kept the general lighting of the level balanced between warm and cool colors and used many neutral lights in the intermediary spaces to keep the choice in the warm/cool crossroads unafflicted. Another example is how we stuck to what we consider the 'neutral' shape in between round and angular geometry (rectangles) apart from the case of the "round/angular" crossroads. One tactic we used for general engagement in the transitional spaces and for equal representation when confronting the crossroads was the architectural element of parallel walls which limits perspective and can achieve awe in the participant (Unwin, 1997). We also used dynamic lighting in a few places to try to excite and engage participants (Seif El-Nasr et al., 2006). A wind sound effect and a droning hum was added to create a suspenseful ambience, to further elevate the engagement of participants.

The order in which these chambers appear is randomly generated upon entering one of the paths. The chunks have also been mirrored, so that each chunk has two versions, allowing for the opposing paths to be positioned both to the left and right relative to the player. The version of each chunk, and therefore the alignment of the paths, is also randomly generated.

With the crossroads, we picked out what we considered to be some fundamental graphical or spatial elements that we could present in a distilled fashion.

The different crossroads, with their opposing paths, are as follows (Figure 1):

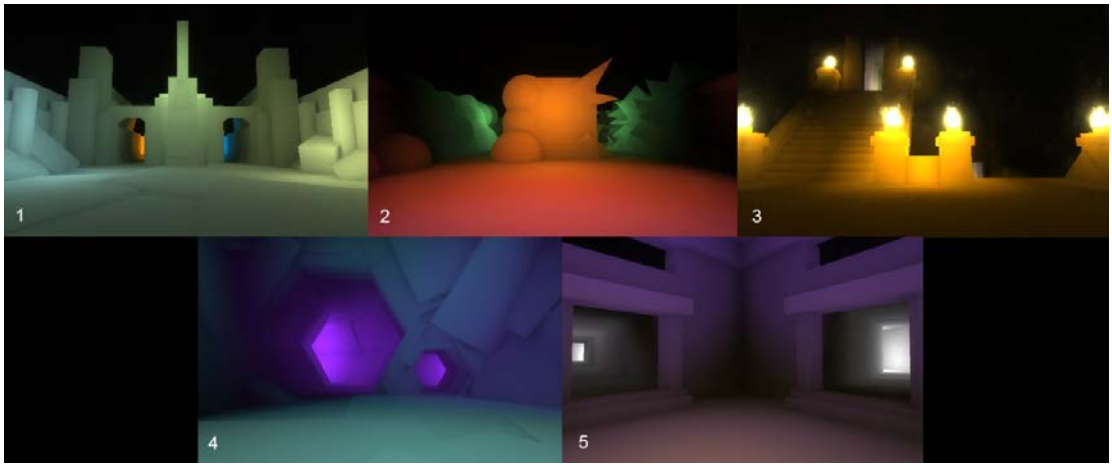

Figure 1: Crossroads, numbered to match descriptions below.

1. **Warm / Cool color**

   This crossroads was created to test if color temperature had a measureable effect on player choice by itself. The chunk containing this intersection was lit with neutral colors apart from the two paths. This is also the only crossroads with contrasting colors.

2. **Round / Angular form**

   This crossroads was created to test if the psychology of shapes, which Solarski (2012) refers to, had effect on player choice. In an experiment, Solarski noted that angular shapes made many players more cautious (2013).

3. **Inclination / Declination**

   This crossroads was created to test if the contrasting connotations of the ascent versus descent had effect on player choice. An example of how this may affect people is the notion of a basic human instinct to climb higher places in order to survey their surroundings (Alexander, Ishikawa, Silverstein, 1977).

4. **Large / Small volume**

   This crossroads was created to test if the contrasting volumes and associated connotations affected player choice. This can be related to what Unwin says about doorways of different sizes having effect on the status relationship between visitor and occupant (1997). We also stipulate that in the context of video games, the path of larger volume can be seen as the main one, while the

smaller one then could be considered a detour or alternative path – perhaps containing some additional reward.

5. **Long / Short distance**

   This crossroads was created to test if the contrasting corridor lengths affected player choice. This is based on Alexander, Ishikawa and Silverstein's points on long corridors (1977). Also, long corridors, especially but not necessarily exclusively in video games, can be seen as a danger zone since the player is essentially trapped (De Jong, 2008).

3.2 Participant Recruitment and Procedure

Participants were recruited by posting a link to a web-player version of the game on social media websites, where they were asked to play a short game. The vast majority of our participants were likely fetched on an indie-gaming forum on a major social media website (Reddit n.d.).

The game starts in a dark chamber with an exit in the player's view. Instructions on how to move around appear in the corner of the screen only to disappear when the player leaves the chamber at which point a *prompt* appears in the middle of the screen. It either says *"ESCAPE!"* in red text or *"EXPLORE"* in blue text, randomized for every played instance of the game. The prompt slides into a bottom corner while the player traverses the randomized level ahead of them. From this point on test data is recorded; including time stamps, path choices, direction choices and order of appearance of chamber types.

The prompt "EXPLORE" is meant to coax players into the exploratory mode of wayfinding, while the prompt "ESCAPE!" is meant to initiate a naïve search (when escaping, one is essentially searching for an unknown target, which would in this case be an exit).

Players proceed by traversing through the level, choosing paths as they go along. Upon entering a path, the entrance behind them is blocked, to stop players from going back and entering the opposing path, forcing players to move onwards.

The game is completed when the player has passed through and chosen a path in each of the five different chambers. Upon completion the player is presented with a questionnaire, where they have the possibility to answer if they were aware that the game was a study and how experienced with games they are. After submitting this questionnaire, pictures of all the intersections arranged by order of appearance appear along with text reminding the player which direction they took. Below is a text field where the player can also freely explain why they themselves think they made the choices they did in the game. Upon pressing enter the written description is recorded and saved to the server.

Figure 2: Sample instance of procedure, a collage demonstrating use of perspective etc. in a playthrough.

4 Quantitative results

4.1 Participants

The results comprises of data collected from 510 participants, of which 389 completed the entire level and every crossroad (see: Figure 3). Since the level was randomized and participants quit or crashed some crossroads were completed more often. The one completed the most was Down/Up at 452 results while Round/Angular suffered the fewest completions at 436 results, however the difference at 3.6% is deemed negligible. Since we consider every crossroads as an individual test, all unique results have been accounted for in our quantitative results, regardless of whether the participant completed all choices or not.

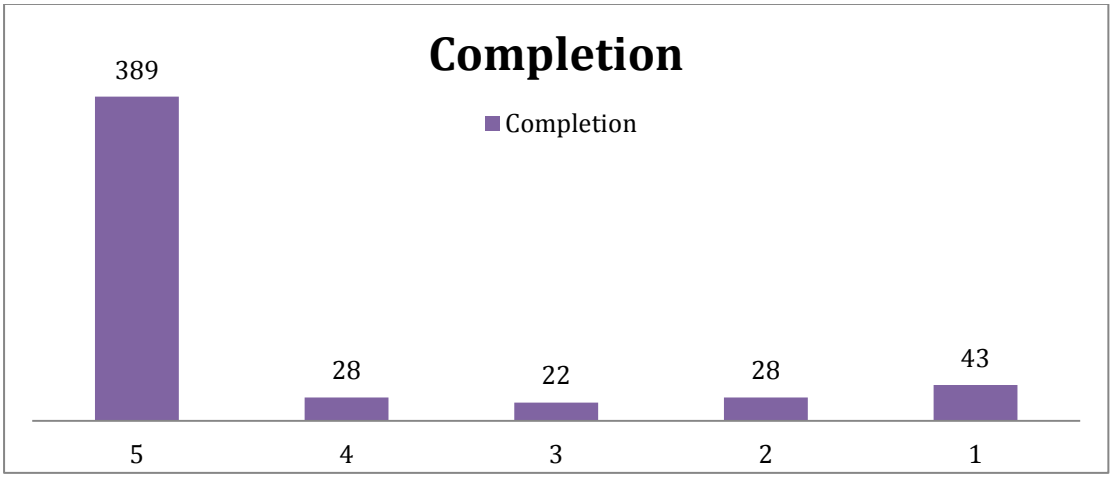

Figure 3: Table of dropouts, x-axis shows at which room players dropped out (five indicating full completion), y-axis representing number of participants.

From the survey at the end of the test where the participants could grade their gaming experience between 0 and 6 we ended up with a mean of 5.4 and a standard deviation of 0.96 from 372 provided answers. 373 participants provided their test awareness; of which 260 reported they were unaware, 71 stated that they realized during, and 42 said they knew beforehand.

4.2 Crossroads results

Hypothesis: Graphical attributes affect path choices.

From the path choices that were registered in the game, preferences were analyzed by establishing the frequency of how many players chose the different paths. When we look at the raw path choices we get strong statistical significance for each except for Warm/Cool which was exactly 1:1 with exactly 223 choices for each side (see: Figure 4).

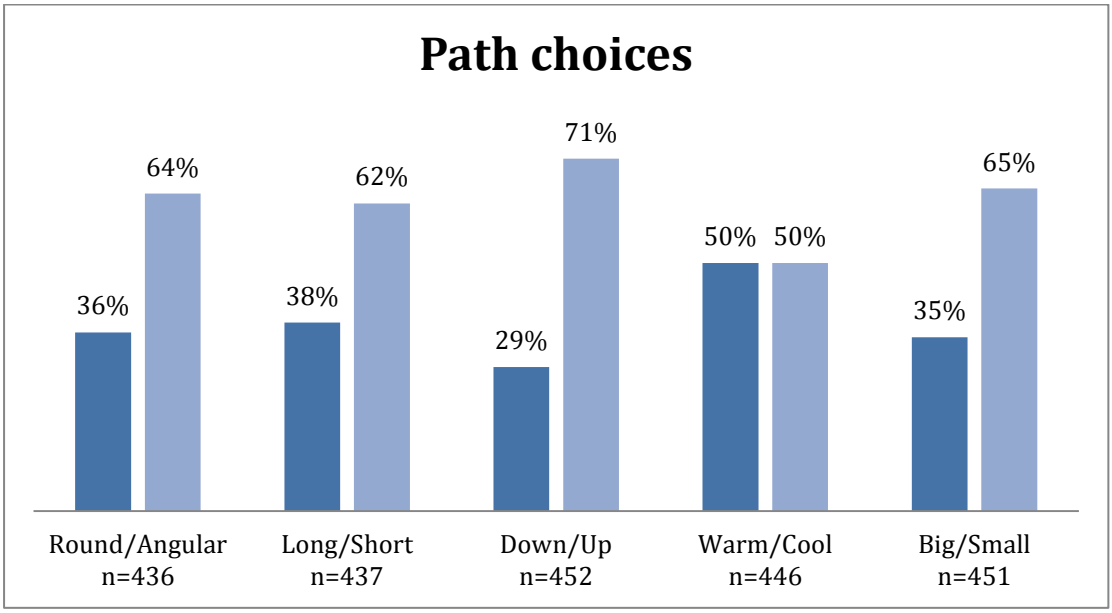

Figure 4: Path choice frequency in percentages. "n=x" shows number of participants that completed that particular crossroads.

As shown in the table: 64 percent of valid participants chose the path attributed with angular shapes versus the 36 percent that chose the path attributed round shapes; 62 percent chose the shorter path contra the 38 percent who picked the longer path; 71 percent chose the inclining staircase over the declining staircase; and 65 percent chose to advance through the smaller tunnel instead of the more spacious one. Using a chi-squared test for each choice resulted in p-values all below .000, except in the case of the choice between the path with a warm color versus the cool color, where the null hypothesis was not disproved with a p-value of 1.000 (see: Figure 5).

Test Statistics

	ra_choice	ls_choice	du_choice	wc_choice	bs_choice
Chi-Square	33,028[a]	23,343[b]	83,265[c]	,000[d]	41,616[e]
Df	1	1	1	1	1
Asymp. Sig.	,000	,000	,000	1,000	,000

Figure 5: Chi-squared tests for each crossroads.

4.3 **Other possible factors**

We collected data on three other factors, separate from the graphical attributes of the paths, to see if the graphical attributes affected path choices independently. These included:

- In which order the crossroads appeared in the individual playthrough (since the order is randomized) – between one and five in other words (0-4 in our data).
- Whether the crossroads was inverted or not (for instance, if the left pathway in the round/angular crossing is round-attributed in the original version, then it is instead on the right in an inverted version).
- The prompt which the participant received, which were supposed to correspond to either an exploratory mode of wayfinding ("EXPLORE") or a naïve search ("ESCAPE!").

A logistic regression analysis was done for each crossroads with three different variables. *Order* (xx_order); *mirrored* (xx_mirrored), which signifies whether the crossroads was inverted or not; and the variable *prompt,* which signifies which prompt the participant has received, "ESCAPE!" or "EXPLORE" (see: Figure 6).

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	ra_mirrored	,344	,207	2,765	1	,096	1,411
	ra_order	-,015	,069	,048	1	,827	,985
	prompt	,144	,201	,511	1	,475	1,155
	Constant	,306	,244	1,579	1	,209	1,358

a. Variable(s) entered on step 1: ra_mirrored, ra_order, prompt.

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	ls_mirrored	,245	,204	1,449	1	,229	1,278
	ls_order	-,133	,071	3,456	1	,063	,876
	prompt	,204	,199	1,050	1	,306	1,226
	Constant	,467	,226	4,265	1	,039	1,594

a. Variable(s) entered on step 1: ls_mirrored, ls_order, prompt

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	du_mirrored	,004	,215	,000	1	,985	1,004
	du_order	**,189**	**,076**	**6,155**	**1**	**,013**	**1,208**
	prompt	-,004	,210	,000	1	,985	,996
	Constant	,601	,215	7,822	1	,005	1,824

a. Variable(s) entered on step 1: du_mirrored, du_order, prompt.

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	wc_mirrored	-,279	,196	2,030	1	,154	,756
	wc_order	-,030	,068	,193	1	,660	,970
	prompt	-,155	,190	,660	1	,417	,857
	Constant	,307	,228	1,806	1	,179	1,359

a. Variable(s) entered on step 1: wc_mirrored, wc_order, prompt.

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	bs_mirrored	-,129	,206	,393	1	,531	,879
	bs_order	**-,264**	**,071**	**13,708**	**1**	**,000**	**,768**
	prompt	,221	,203	1,190	1	,275	1,248
	Constant	1,124	,232	23,486	1	,000	3,077

a. Variable(s) entered on step 1: bs_mirrored, bs_order, prompt.

Figure 6: Logistic regression analysis of other possible factors.

Only in two cases do we consider the variables statistically significant. Firstly, *du_order* in the Down/Up crossroads in which a later appearance resulted in an increased tendency to go up the stairs. Secondly, *bs_order* in the Big/Small crossroads in which a later appearance resulted in a reduced tendency in going through the smaller tunnel (see: Figure 7).

No other variables proved statistically significant in our results. In other words mirroring and the Escape/Explore prompt had no clear effect that impacted on the quantitative data.

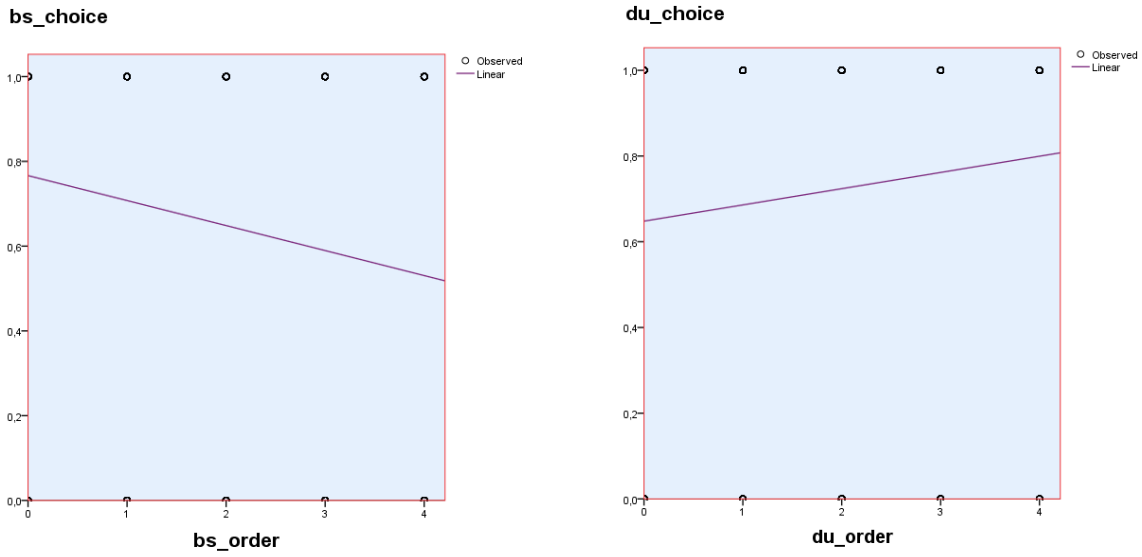

Figure 7: Graphs demonstrating choice/order relationships.

The values on the x-axes corresponds to the order of the crossroads (*bs_order* and *du_order*), where 0 signifies the first appearance and so on. The values in the y-axes represent mean path preference where in the case of *bs_choice* a higher value signifies a preference for *small*, while a higher value in *du_choice* corresponds with a preference for *up*.

4.4 Choice patterns

Additionally, we analyzed correlations to observe if certain path choices were often made in tandem with other path choices (see: Figure 8).

Correlations

		ra_choice	ls_choice	du_choice	wc_choice	bs_choice
ra_choice	Pearson Correlation	1	,001	**-,088**	-,061	,018
	Sig. (2-tailed)		,977	,072	,221	,720
	N	436	408	419	410	412
ls_choice	Pearson Correlation	,001	1	**,091**	-,077	**-,113***
	Sig. (2-tailed)	,977		,063	,119	,022
	N	408	437	418	411	413
du_choice	Pearson Correlation	**-,088**	**,091**	1	-,010	-,068
	Sig. (2-tailed)	,072	,063		,841	,161
	N	419	418	452	425	423
wc_choice	Pearson Correlation	-,061	-,077	-,010	1	,018
	Sig. (2-tailed)	,221	,119	,841		,715
	N	410	411	425	446	414
bs_choice	Pearson Correlation	,018	**-,113***	-,068	,018	1
	Sig. (2-tailed)	,720	,022	,161	,715	
	N	412	413	423	414	451

*. Correlation is significant at the 0.05 level (2-tailed).

Figure 8: Choice correlations table. Underscored variables mentioned in text.

There is a statistically significant correlation between *ls_choice* and *bs_choice* where players choosing to go through the shorter corridor are also more likely to go through the bigger tunnel. The tendency is not massive though at an R^2 of 1.3%, but we expect subtle results if any (P-value = .022, Pearson correlation = -.113). Additionally, two statistically indicative correlations were observed, *du_choice* with *ls_choice* and *ra_choice*, but these can be disregarded as negligible as their influence is infinitesimal. The reason we could get any significance is due to our substantial data set.

5 Qualitative results

Out of our qualitative responses we received 238 usable instances, of which fewer were substantial enough to be useful. These were read through and analyzed to find recurring themes.

From them we could decipher eight patterns in attitude or play style: **challenge**, looking for dangerous or otherwise challenging situations; **safety**, contrary to the former attempting to take the safest route; **'hipster'**, trying to be unpredictable or different; **exploratory**, focusing on exploring what is perceived to be 'off the beaten path' or looking for hidden objects; **effective**, choosing the faster route; **systematic**, having a systematic approach to not get lost or solve a maze structure – seemingly more common with the "Escape" prompt; **random**, expressing not knowing why taking certain paths; and **aesthetic preference**, stating that path choices depended on what was thought of as prettier or more interesting.

Examples of responses from participants that were categorized into the pattern **challenge** are:

> "The sharp angles implied there may be some type of obstacle or conflict, and I was hoping for something like that."
>
> "spikes= danger = a challenge"
>
> "I chose the path with more protrusive obstruction."

Examples from the contradicting pattern **safety**:

> "I believe I took (almost subconsiously [sic]) what appeared to be the safest path. The only part where I stopped to considder [sic] safety, however, was when I was faced with the bramble-like area versus the safer bubbles. I must also say, the meshes and lighting in this game are amazing, it's so smooth. Playing this game is as satisfyingly fluid and sweet as cutting through a microwaved marshmallow."
>
> "Rounded bubbles by safety"

> "Smooth is safer than spiky [...] The smaller tunnel is less open and more secure. […] I prefer left over right and the hallway is shorter, and thus more secure."

In the cases of these patterns of danger versus safety, most responses were attributed to the angular versus round crossroads. The other patterns tended to be less specifically attributed.

Examples from the pattern which we decided to call '**hipster**':

> "I tried to think in game mechanics and which way a regular player would go and did the opposite."
>
> "I just went left all the time, because usually people go right."
>
> "a lot of times in games like this I try to do what the creator expects me not to do because usually they try to counter whatever the player wants to do."

Examples from the pattern **exploratory**:

> "And for the last, big passages in games tend to indicate where you're "supposed" to go" (went through the small passage).
>
> "In some cases, I went with the one I thought was "less obvious" or "less appealing" because I was more curious what was "off the beaten path" which Is a general gaming instinct I have."
>
> "Then I went down because in most typical games the least obvious route would yeild [sic] the greatest treasure, so I figured the lower the better"

During deciphering, these two categories were separated, having initially been the same. There is some overlap, but what we think defines *hipster* is a matter of identity building rather than simply doing something different. Looking back at the 'pleasures of games' that Salen and Zimmerman account for (2004), this could be related to LeBlanc's 'Expression' (Games as self-discovery) or Michael J. Apter's 'Negativism' (deliberate and provocative rule-breaking). The *exploratory* pattern, on the other hand, we would relate to LeBlanc's 'Discovery' and Apter's 'Exploration'.

Examples from the pattern **effective**:

> "Right looked closer, quicker to explore."
>
> "Down in video games is usually where hidden things are, but I was impatient and just went up"
>
> "It was the fastest way to not have to think about my choice."

… And **systematic**:

> "Always turning in one direction is a surefire way to complete a maze structure, assuming you started at an outer wall and the level map can be drawn in 2d."
>
> "I thought it was a labyrinth, so I always chose right."
>
> "Follow the right."

Examples from **aesthetic preference**:

> "They looked cooler and more intriguing."
>
> "Whichever path looked the most superficially interesting."
>
> "I found the first two right paths more interesting. Then at the third choice i realized it was a study so i continued the trend."

… And **random**:

> "Not sure, some were impulse decisions"
>
> "idk... mental coin flips."
>
> "Random, no decision involved."

We have used these patterns to primarily describe our qualitative results, not to lay down a theoretical framework for players' explorative attitude types or thought processes. However, some of these patterns and their associated choices, in their prevalence, can prove useful in understanding why some paths are more popular than others.

6 Mixed analysis

The quantitative findings show that some paths were more popular with participants than others. Here we will try to interpret the results and discuss possible reasons for the frequency of chosen paths, and examine the qualitative answers to find possible explanations for this.

We discuss each crossroads separately, followed by a general and correlating analysis.

6.1 Angular versus Round

As we saw earlier, a majority of the participants chose the path attributed with angular shapes. According to the psychology of shapes that Solarski (2012) accounts for this would be considered as the more dangerous path. Contrary to this, the path attributed with round shapes would be considered as the less challenging path. A possible explanation for the frequency of this choice can be that the participants actively sought out the path which they considered more dangerous, because often when playing games, players will want to meet some resistance. This is also something that Salen and Zimmerman (2004) account for in their discussion of the pleasures of games. Challenge is seen as a key element in the enjoyment of games, and as such it is understandable that players might seek a more dangerous looking path. This behavior is reflected in the qualitative results, where a substantial set of participants explained their choice of the angular path as a way to seek challenge.

A possible reason for this challenge or danger preference can be our test population's proclaimed high level of gaming experience. Experienced gamers might be more likely to seek out challenge because of their confidence in the medium. In Solarski's (2013) experiment, inexperienced gamers proved more cautious.

Different players will however have different reasoning when making their choices. For instance one participant's answer reflects that they avoided the path attributed with round shapes because they thought the seemingly harmless path would hurt them, as if it were a deception*; "I went left* [sic] *because I thought that*

the seemingly harmless left path would hurt me". (According to the collected data, this participant took the angular path, which was actually positioned to the right, and the given answer we interpret as a mistype). This type of behavior will contrarily reflect the pattern of 'safety' from the qualitative results, and is a way to actually avoid danger. However, participants' pertaining to challenge-seeking was more common in the answers from the survey.

6.2 **Long versus Short**

A majority of participants chose the shorter path over the longer. A possible explanation for this could be because players might want to take a quicker route and as such a shorter path would allow for traversing the level faster, reflecting the pattern 'effective' from the qualitative results. For example, one participant wrote in an answer: *"I just wanted to get to the end".* Answers like this are however not very prevalent, and another possible explanation can reflect the idea that long corridors are experienced as discomforting, according to Alexander, Ishikawa and Silverstein (1977).

Another possible explanation for this behavior can be related to the point that De Jong (2008) makes about long corridors in games; that long corridors essentially trap the player in an overly fixed linear path with only two exits. Since our test population in other aspects seemed keen on seeking out challenge, one might think that this would have resulted in more participants choosing the long corridor. On the other hand, it can be seen as an unnecessary type of challenge, where if the player would meet resistance, would be restricted in the possibilities of facing it.

As Alexander, Ishikawa and Silverstein (1977) suppose, long corridors can be experienced as tedious and uneventful to traverse, something that De Jong (2008) also claims is relevant in games. From our own experience in real life, we feel ready to agree that long corridors might be perceived as slightly tedious.

There might also have been some serious problems with this crossroads which might have heavily altered the results, elaborated upon in the Discussion chapter.

6.3 **Inclination versus Declination**

The inclining staircase proved more popular, which can possibly be explained by its reported positive connotation. In a few cases, participant's answers reflect a connection to heaven and hell, the inclining staircase corresponding to heaven and the declining staircase to hell. For instance, one participant's answer possibly reflects that of the enjoyment of challenge, choosing the declining staircase to reach hell; *"When faced with two staircases, I chose to go down because I thought it would correspond with hell, and hell sounded more interesting to me".* Most participants however, seemed to seek reward in this case, where heaven can be seen as the ultimate reward; though generally using different wording. To summarize, participants often drew a connection between going up as something positive and down as something negative. Also, participants in this sort of test might be likely to rationalize, demonstrated in the often speculative responses. If it is a basic human instinct to climb high places, like Alexander, Ishikawa and Silverstein (1977) suggest, it might be that people are trying to rationalize this instinct. In any case, our results could support such a thesis.

Another factor in this equation is as several participants have remarked that the exit through the upper chamber is visible from the foot of the stairs: *"I suppose I went up instead of down because I could SEE the path initially as opposed to going down stairs.";* and another said *"I could see where the exit already* [sic] *so it seemed a safer choice".* Additionally, one participant remarked that his/her choices of *small, short* and *up* related to the levels of obscurity invoking curiosity. *Up* hinting at an interesting chamber by showing more while *small* and *short* piquing interest with the opposite: corners obscuring what lies ahead. This relates to Unwin's points about interplay between lines of sight and lines of passage (1997). Declinations and inclinations have various natural impacts on this interplay; however it might not be the case that downward paths are generally more obscured, as in the case of our crossroads, since an inclination otherwise could block the sight of whatever is beyond or above it. This might have been a problem in our test design, which will be discussed further in the Discussion chapter.

As shown in the results, a later appearance of the crossroads containing the inclining/declining staircases resulted in participants more frequently choosing the inclining stairs. A possible explanation for this could be that as players spent longer

time in the level, they became less interested in seeking out alternative paths and rather wanted to complete the level. Up could more often have been interpreted as the main path, the one leading to the end, as supported by a few responses – for instance: *"Down in video games is usually where hidden things are, but I was impatient and just went up".* This, we postulate, might explain the relationship between 'up' and 'order', but is likely not the reason why 'up' proved more popular overall – discussed further in the following section on the Big versus Small crossroads which contrasted this result. In short, we believe the positive association, levels of obscurity and/or the basic human instinct were the main reasons for Up's statistical advantage.

6.4 **Big versus Small**

As stated, the tendency to head for the perceived main path in a later appearance of the intersection in the test can be observed in the case of the Big versus Small crossroads as well; however, in this case the perceived alternative route (Small) was overall more popular. We even believe this alternative attribute might have been the most compelling factor; choosing the smaller tunnel more frequently than the big tunnel when they may have perceived the big tunnel as the main path. Choosing the smaller path may have been a way to try to explore the whole level in its entirety before advancing further. It is for instance common in games that objects are hidden in small nooks and crannies, and that exploring the level will reward the player in finding the hidden objects. This is related to our pattern from the qualitative results that we refer to as 'exploratory'. An example of this behavior is reflected in one participants answer; *"Towards the end I saw two tunnels of a hexagonal shape, with green lights* [sic]*, and I took the smaller one because it felt cozier and I tend to feel like things are hidden in small spaces. I also found myself trying to squeeze into tight spaces looking for easter-eggs, in other areas."* (The paths in this crossroads were actually lit with magenta color, and the mix up may be due to a fault in the color representation in this instance of the application).

A few participants mentioned that they felt that the smaller path was better fitted to the player character in relation to its size; *"I thought I fit in better in the smaller hole",* which might with a stretch connect to ideas about status relationships between visitor and occupant (Unwin, 1997). Others expressed it to be a simple

matter of preference when it came to choosing between the big and the small path; *"Bigger tunnel looked more ineteresting* [sic]*".*

6.5 **Warm versus Cool**

The results in the Warm/Cool crossroads simply seem to be a matter of preference. A couple of participants reflected over the color temperature; one example connoted the warm color with fire and danger and preferred that: *"took red because it made me think of fire and in puzzle/escape games where your only implication of what is in a room is the color of light emiting from it, I'll usually pick the one that might be more "dangerous" (for lack of a better term)".* However a sleuth of responses concisely expressed an aesthetic preference of one color over the other, linking it to our pattern of 'aesthetic preference'. The results were indecisive; this element of color contrast did not result in a quantifiable wayfinding preference. This suggests that designers may give these colors designed contextual connotations – their own meanings.

6.6 **General analysis**

Since the level was distributed on an indie-gaming thread on a social media website, we assume that most of the participants share an interest in games, and as such have some experience in gaming. From the form in the test where the participant could grade their gaming experience between 0 to 6 we ended up with a mean of 5.4 and a standard deviation of 0.96. This can be an explanation for why many chose the smaller path, because they have a habit from other games that allow for players to search though the level for hidden objects. This can also explain why many participants chose the seemingly more dangerous, angular path, since they seek out challenging gameplay.

As touched upon previously, a later appearance of certain crossroads resulted in a statistical difference. A reason for this could be declining engagement; they became on average increasingly disinterested the more time they spent in the level. Also, they might have realized that the game was an experiment, which might have contributed to this disinterest, and thus became less inclined to explore or seek out challenging situations.

Although many of the answers supplied in the open-ended questionnaire at the end of the game reflected theory, and our own thoughts, there was a large variety in

explanations. It is clear that a lot of participants had very different reasoning when choosing paths and some participants did not reflect over which path they took and why. This makes it harder to draw general conclusions on why people choose certain paths over others, but on the other hand the statistics show that certain paths were much more popular anyway. A possible explanation for this can be that the graphical contents and the design of the paths affect players in a more subtle way, influencing choices at a subconscious level.

7 Discussion

Regarding the inclination versus declination crossroads, one could see more of the room in the upper chamber compared to the lower one. Many respondents cited this as a reason for their choice of ascent. After reflecting over this, we conclude that this may very well be a deficiency in our test; since we do not think this difference in path obscurity is inherently associated with these contrasting features. It might even be the other way around; that an upper area is more obscured since the inclination may block line of sight from the bottom. These levels of obscurity may affect curiosity, influenced by mystery which is the word Unwin (1997) explicitly used, which may have affected the statistics of this test. It could then be said that we failed to properly distill this contrasting element; that we should have revised this section with further considerations.

There was also an obscurity issue with the long versus short corridor crossroads where some participants expressed that they did not notice the difference between the two paths. Due to the angles of the corridors relative to the chamber, one could not see the difference in length until at the precipice of the entrances. Although effort was made to keep both alternatives at equal levels of illumination, the shorter path seemed to be more lit than the other when approaching. This could have had serious implications for the purity of this part of the test as this could have been the main reason for the shorter path choice's numerical dominance.

Something that can be conceived of as problematic and which possibly had an effect on the outcome of the test is the fact that the round and angular paths were lit with green color. The reason this might have been a problem is because a few participants have in their answers associated the round and angular paths with vegetation, likely due to the green color. For example, one participant responded with: *"The only choice I conciously* [sic] *remember making was to go left at 3, because the trees looked thicker and I equated that with better chance of escape".* When creating the crossroads we wanted to create tests where the graphical elements were distilled and would speak for themselves, allowing for

participants to be affected by whatever connotations come to mind from these. In this case however, our portrayal may have affected the possible connotations to be slightly shifted towards ones of vegetation and similar, by using green color. This was not a conscious choice and was not taken into proper consideration when creating this crossroads.

We did not isolate statistics of path choices from the group of participants who left answers in the end-game survey to see if they differed from the rest of the population. This can be seen as problematic, since if this were the case, then our qualitative data would not be representative of the population as a whole. A statistical analysis of this group's results could have been done to ensure that they were representative of the entire population, and likewise the qualitative data. If this would have been proven to not be the case, this would have to be taken into consideration also. The same could perhaps be said about those who quit or crashed before completing the whole test.

Since our test group was mostly assembled on one site and admitted a high level of gaming experience, it is likely that our results would not reflect that of a wider and more diverse group. Specifically, we think that an inclusion of a group inexperienced in video games would have been relevant, especially considering our citation of Solarski's (2013) test where there was a clear difference between these groups of contrasting experience levels.

In our results, the prompt did not show a statistically significant effect. It may be that the prompt was not sufficiently eliciting. These prompts could have been bolstered by various devices to give a more potent impact; an example could have been a stressful sound accompanying the 'ESCAPE!' prompt. One could argue though, that such additional devices could have intruded on the test in other ways.

Participants were not limited in repeating the test, which seems to not have been very uncommon from accounts in the qualitative data. This was accompanied by the fact that we did not implement functionality to discern whether a participant was repeating or not. This could very well have had effects on both our qualitative and quantitative data. Several accounts revealed that participants repeated the test to see what opposite path choices would lead to; if

this was a frequent kind of occurrence it would likely suppress the binary choice results. It could perhaps also be argued that certain player types associated with certain path choices were more likely to repeat the test than others. This could lead to either an overrepresentation in this group's results if they repeated their choices or a dilution if they tried the contrary alternatives. Whatever their effect, the factor of repeating participants muddies our data.

There were some technical issues with the test application. One being that mirrored versions of the rooms made up for 60% of the intersection instances, likely due to a programming error. This resulted in participants faced with mirrored versions making up a larger group. Thanks to our population size though, it is hard to argue that it had any serious effect on the results. Another problem was that a select few participants managed to reach a higher number of choices than five, only their first choice of each crossroads was registered in our data, however.

There were a number of design issues with our optional descriptive response functionality that were detrimental to the quantity and quality of our qualitative data. The text field box where one would enter a response had a large y-scale and apparently did not automatically change lines when entered text spilled outside its right-hand border. This urged participants to press the 'Return' key in order to make a line break, but this key was programmed to post the results to the database which resulted in them posting an incomplete description. This programming was described on the screen in text, but this text was slightly obscured by the opacity of the text box. Naturally, we got a lot of incomplete responses due to this issue. Others may have repeated the test to enter their response anew, only to be faced with a randomized instance of the level that differed from their original playthrough in order and layout. Additionally, participants running the application in a browser on a Mac were unable to post their results at all due to different naming of keys. Some victims of these issues posted their responses on the forum board of the test link though, which were then accounted for in our qualitative analysis.

There is a lot of noise and many contributing psychological and circumstantial factors determining a participant's choices. It is possible that a new environment

construction in a replicated test could harvest very different results from subtle differences in design, even with a similar participant population.

8 Conclusions

With the study we wanted to gain knowledge about if and how graphical attributes can affect players' choices in wayfinding. With knowledge like this one can make informed design decisions that contribute to more well-crafted experiences.

We asked the question "Can graphical elements affect the route which a player takes while exploring an unknown 3D environment?"

As shown in our results certain paths were more popular and we draw the conclusion that graphical attributes impacted on players' wayfinding choices.

The results from our population showed that:

- Round versus Angular showed a preference for Angular; from our qualitative data we could see that Angular was associated with danger and thus greater challenge and/or reward. This, we stipulate, contributed to the preference.
- Long versus Short showed a preference for Short which was often referred to as (quite correctly) the quicker route. This seems to be one of the reasons for its statistical preference, though it can possibly be explained by the assumption that long corridors are experienced as boring. Alternatively, the preference was due to an incidental illumination advantage.
- Inclination versus Declination showed a preference for Inclination where it was often seen as the metaphorically positive path. It may likely be tied to a drive to climb up to survey one's surroundings, which may or may not be a basic human instinct.
- Warm versus Cool showed no statistical preference, where personal taste in color seemed to be the deciding factor in a large part of our qualitative responses.
- Big versus Small showed a preference for Small, the path which many participants wanted to explore in search of secrets.

Our interpreted qualitative pattern of 'hipster' sparked some interest in us. The type of social awareness evident in this group that reacts with a sort of prejudice against the designers of the experience or other participants could be an interesting object of a study.

Our population was limited in that its average self-proclaimed gaming experience was very high (5.4/6). In future studies, it could be worthwhile to gather a more diverse population. With such a population, experience will potentially prove a factor in preferences.

Another way future studies could expand on this subject, is by combining the different graphical attributes and examining the effects of these combinations. For instance, could the combination of warm/cool lighting and an ascending/descending staircase intersection further affect the results of such a crossroads?

It is possible that a replicated test could yield very different results from subtle differences in design, and even more so with a more diverse group. If this test was to be replicated and repeated, it could greatly strengthen our conclusions if results were congruent. If they were not, that in turn could open up for study of the inevitable subtle differences between the tests which could then lead to interesting new conclusions.

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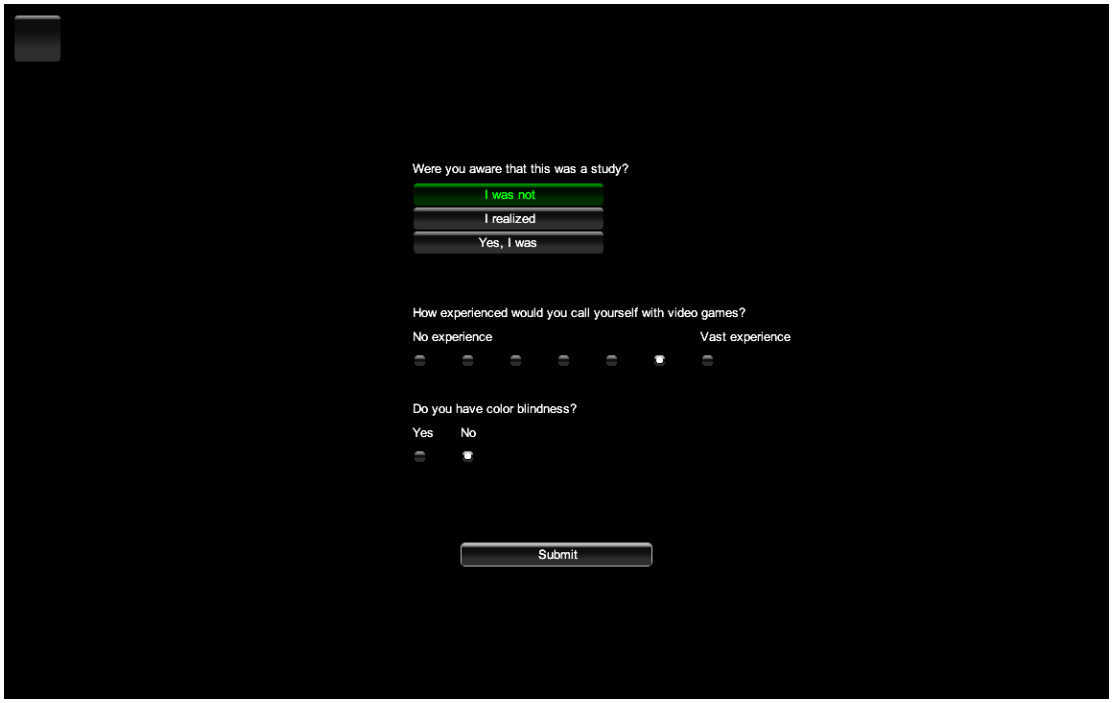
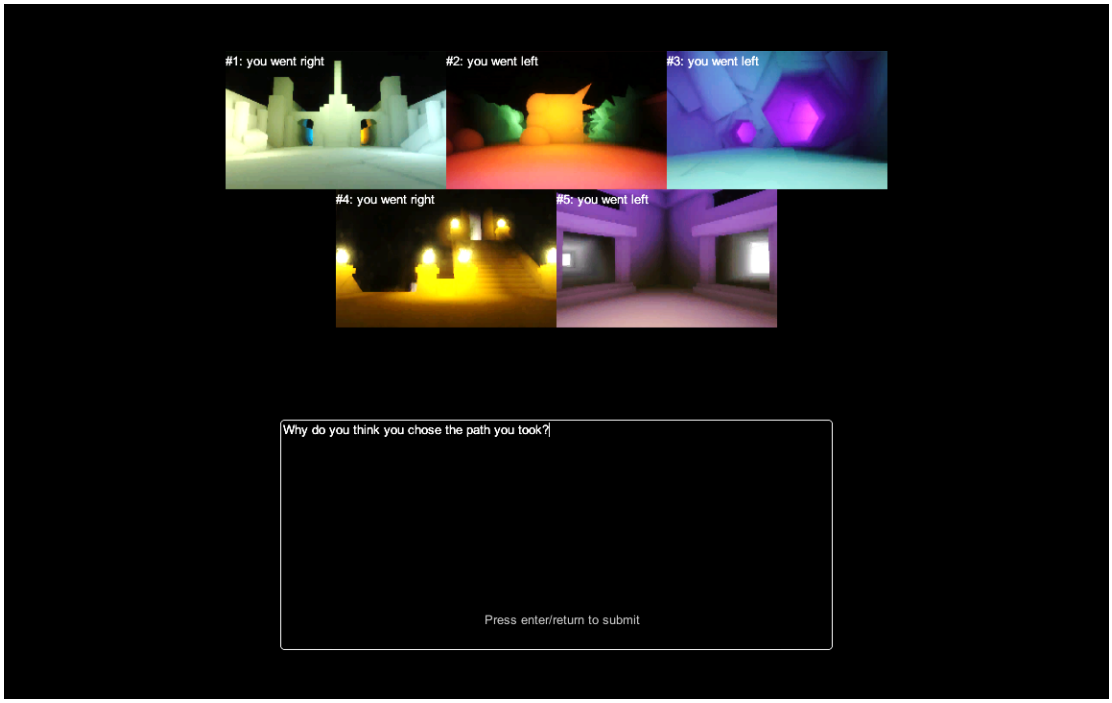
Appendix

Survey data collection screendumps:





Survey questions:

- Were you aware that this was a study? (Answer alternatives: *"I was not"*; *"I realized"*; *"Yes, I was"*)
- How experienced would you call yourself with video games? (Checkbox linear scale with seven discrete steps)
- Do you have color blindness? (Answer alternatives: *"Yes"*; *"No"*)

Link to game: http://manshultkrantz.se/unknown/unknown.html