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An Investigation of Methods For Placing Virtual Objects in 3D Computer Games

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Abstract:

This project seeks to investigate methods for placing virtual objects in 3D computer games. There seems to be a lack of research in this area, which gave the main motivation for executing this project. The article starts by defining a problem statement, discussing motivation and delimitation, before diving into experimental design, centered around usability and continuation desire user testing. Due to the lack of research in this field, a taxonomy of placing objects in games was proposed in the article, with a small example table showing a practical application. Hereafter a survey among Minecraft players was conducted and revealed that the camera perspective seems to have an impact on Minecraft player's building behaviour. Therefore, the first iteration was focused on camera perspectives and thus tested three different camera perspectives against each other. The conclusion was that the first person camera perspective was generally preferred. The next iteration was focused on rotation schemes testing, and included two versions each with two rotation schemes, one based mainly on the mouse against another scheme based mainly on the keyboard. No significant differences were found between any of the rotation schemes. The article ends with a discussion of the data integrity, covering subjects such as bias, favourable conditions and independent variables, before the conclusion. A small future perspectives section is the final part of the article, before the bibliography.

Building Blocks

An Investigation of Methods For Placing Virtual Objects in 3D Computer Games

Rami Ahmed Bock and Daniel Thormod Staal

May 23, 2013

Contents

1 Introduction

This project seeks to investigate the action of placing virtual objects in real-time 3D games. A long list of games today incorporate some form of placing objects, often associated with building structures or defenses in war games. However, not much research exists in the field of placing virtual objects, meaning that the industry cannot rely on scientifically valid user tests or research, but instead they seem to make experience based choices. Therefore, this project seeks to examine certain aspects of placing objects, with a focus on user testing. By executing a few smaller iterations with testing phases, a few aspects related to placing objects can be researched and perhaps provide precedence to other researchers interested in the same field. Since there seems to be a lack of research in this area in the academic community, this article starts by proposing a taxonomy for classifying and categorizing games that incorporate placing objects. In order to execute user tests on interesting aspects in relation to the selected field, a small prototype was iteratively designed and implemented in this project.

1.1 Motivation

The motivation for this project mainly stems from the fact that there seems to be a lack of research in this area, thus providing an opportunity for researching a relatively new area with very little if any related work in the academic field. Additionally, this project is actually a subpart of a larger 3D game development project, in which the action of placing objects will be incorporated. Even so, the main focus for this project was not game design or implementation, but rather the experimental design and testing. User testing was meant to grant the necessary results for further development of virtual object placement systems.

A problem statement has been formulated for this project, to serve as a frame for testing hypotheses, as well as the design and development of experiments and prototypes:

In which ways can virtual objects be placed in real-time in a 3D game, and how will these influence players' desire to continue placing objects?

1.2 Delimitation: Alternative Input Devices

There are many ways the problem statement could be approached, and naturally not all of these methods can be explored in this project. While most people are used to using standard human interface devices such as the keyboard and computer mouse, there exists a multitude of alternative input devices. However, in this project it was decided to limit the scope to only using the most common input devices: the mouse and keyboard.

Figure 1 – *This image shows a multi-button mouse, with a numpad on the mouse itself. The picture was taken from Razer's official website (Razer, 2013b).*

Alternative input devices such as pointing devices (Kaneko, Ledbetter, Adams, & Siddiqui, 1997; Zhai, Smith, & Selker, 1997) , smart phones (Ballagas, Borchers, Rohs, & Sheridan, 2006), touchpads (Logan & Evans, 1994), joysticks (Chen, An, Osborne, DiLascia, & Coill, 1998), custom keyboards or mice (Niedzwiecki, 1999; Logitech, 2013; Razer, 2013a), and other alternative devices (Zhai, 1998) were disregarded in this project. This includes multi-functionality mice such as Razer's 'Naga Molten' (Razer, 2013b), which is depicted in figure 1 on page 1. Camera tracking technologies, such as the XBox

Kinect (Microsoft, 2010) and Nintendo Wii (Nintendo, 2006), were also disregarded in this project.

Thus, based on the delimitation, this project was limited to using solely common keyboards with number pads (also called numpads), and common computer mice with two buttons and a scroll wheel. With the focus on user tests, the experimental design was considered very important.

1.3 Experimental Design

In order to ensure relative comparability between the user tests executed in this project, a single experimental design framework was designed. The experimental design in this project resembled to some extent a classical, controlled experiment, where cause-and-effect relationships are examined (Rubin & Chisnell, 2008, pp. 23-24). This entails formulating a null hypothesis for each test and using either one-way single variance analysis (ANOVA) or t-tests to confirm or reject the formulated hypotheses. Each test incorporated at least two different scenarios for comparison, ideally with only a single independent variable between the scenarios[1]. Quantitative data was gathered through Likert scales to be used for the hypotheses testing, while qualitative data through open-ended questions were used as indications towards reasons for the results and reveal potential issues. Thereby usability testing could be used in the context of this project.

1.3.1 Usability

The problem statement proposes a way to test, namely on players' desire to continue, which could be evaluated by a form of usability testing. One of the basics of usability testing is to utilize "*Observation of end users who either use or review a representation of the product.*" (Rubin & Chisnell, 2008, p. 25), which was fitting for this project due to the fact that tests were conducted on a prototype (a product). There are many aspects which could be tested in conjunction with the problem statement of this project, thereby an iterative development and testing method would be optimal. This means that using feedback from prior iterations could improve later iterations, which is another basic point of usability testing: "*Recommendation of improvements to the design of the product*" (Rubin & Chisnell, 2008, p. 25). However, since there are many forms of usability testing with varying relevance for testing of a prototype game, it was a requirement that the testing framework used in this project was suitable for testing games.

1.3.2 Desire to Continue

There are a multitude of concepts which could be used to analyze players' willingness to continue in games. Player engagement is one of the most researched dimensions of playing games (Dickey, 2005; Reeves & Read, 2009), but because of its multi-dimensionality it can be related to many other concepts such as Immersion (McMahan, 2003; Brown & Cairns, 2004; Ermi & Mäyrä, 2007; Jennett et al., 2008), Fun (Schlenker & Bonoma, 1978; Binmore, 1992; Koster, 2004), Flow (Csikszentmihalyi, 1991; Chen, 2007), Gameflow (Sweetser & Wyeth, 2005; Jegers, 2007) and Presence (Lombard & Ditton, 1997; Tamborini & Skalski, 2006) among many others, which all have differences in how they understand engagement and how they measure it (Schoenau-Fog, 2011a, p. 220). While it is practically impossible to test for all these concepts simultaneously, there is a framework that claims to capture most of these concepts in one. The Player Engagement Process (or PEP) (Schoenau-Fog, 2011b), which set the foundation for the later Engagement Sample Questionnaire (ESQ) (Schoenau-Fog, 2011a, p. 221).

According to its author, the ESQ is a valid testing method for examining whether players want to continue and what factors con-

[1] It might be practically impossible to truly eliminate all independent variables, due to the nature of games.

tribute to their wanting or not wanting to continue. The ESQ is meant to be used together with an intrusive method, where players of a game are interrupted with a part of a questionnaire. As the author writes: "*The intrusive method and ESQ can address this issue [users' motivation to continue despite tragic events] by investigating whether users still want to continue due to aspects other than enjoyment, fun, flow, pleasure and similar 'positive' facets of engagement.*" (Schoenau-Fog, 2011a, p. 227), meaning that the ESQ and intrusive method should be able to measure many aspects simultaneously related to the experience of playing. While the first version of the ESQ was designed to test all aspects of the PEP, including the narrative in the game, a further developed and more condensed version of the ESQ exists, which is more suitable for non-narratively driven games or applications (Schoenau-Fog, Birke, & Reng, 2012).

1.3.3 Experimental Design Conclusion

Therefore, a permutation of the continuation desire framework was used. Some of the questions were formulated in a way that moves away from the ESQ, but instead approaches usability testing. An example of a reformulated question was the Likert scale questions, which in normal continuation desire testing would be "*Please indicate the extent to which you agree or disagree with this sentence: "I want to continue playing"*" (Schoenau-Fog et al., 2012, p. 2). In this project these questions were reworded to approach usability testing, by asking "*Please indicate the extent to which you agree or disagree with this sentence: "I would like to use this [implementation] when building in-game"*". The words 'use this [implementation] when building in-game' would indicate that test participants should disregard other aspects of the prototype game, and not expect to continue with the same scenario. The test framework generally resembled continuation desire more than usability testing, which is why the scale was still called 'continuation desire' in this project. As such, the testing method designed for this project could be said to be a mixture of continuation desire and usability testing. A mixing of methods is actually recommended in some cases: "*One discovers that there is no "winning" design per se. Rather, the best design turns out to be a combination of the alternatives, with the best aspects of each design used to form a hybrid design.*" (Rubin & Chisnell, 2008, p. 38). In essence, it could be said that the continuation desire framework was used to test usability of a particular aspect in the prototype game. By using the same testing method across different tests, the gathered data was expected to be relatively comparable, since the same scales and the same way of formulating questions was utilized.

However, since little or no research seems to exist in the field of placing objects in games, this project starts by proposing a taxonomy.

1.4 Background: A Taxonomy of Placing Objects

The 'Taxonomy for Placing Objects in Games' was formulated by looking at a range of games, which all in some form incorporate the action of placing objects in 3D games. The taxonomy loosely draws inspiration from other game-related taxonomies, such as (Crawford, 1984; Klabbers, 2003; Hunicke, LeBlanc, & Zubek, 2004; Lewis, Whitehead, & Wardrip-Fruin, 2010; Popescu & Belotti, 2012). A distinction has been made between 'placing' an object, and 'dropping' an object. Most first person shooter (FPS) games allow players to drop their currently selected weapon, which is an example of what does not count as placing objects. Six categories for the taxonomy were defined, each with two or more possible 'states' or 'values'.

— **Camera Perspective** shows how the camera is handled by the game, which kind it is and whether players can change between perspective. The perspective could have a substantial impact on how easy or hard it is to place objects accurately.

- **Perspective or Orthogonal** states whether the camera has perspective, or simply put whether parallel lines converge towards the horizon or not; perspective does converge and orthogonal does not.
- **Camera Type** can be either first person (from the eyes), third person (from the shoulder or above head), axonometric (viewed from a skewed direction to show more than one side) or top-down (bird's perspective).
- **Toggleable** either toggle or no toggle, which states whether players may change camera perspectives in-game or not.

— **Overview** can be facilitated by the game, usually in the form of a map (either mini-map or a fullscreen map). The possible overview affects players' ability to place objects.

- **None** is when the game does not facilitate overview at all.
- **Mini-map** is when the game provides a small 2D rendering of the entire map, usually placed in one of the corners of the player's screen.
- **Full map** is when the game provides a large 2D rendering of the entire map, usually placed in the middle of the player's screen and brought up by pressing a keyboard button, often 'm'.

— **Module Scale** concerns the size or scale of placeable objects. Some games even have more than one scale of objects.

- **Structures** are whole, complete objects, usually a whole building. They cannot be combined with other structures and are as such 'standalone'.
- **Sections** are part objects, usually a section of a whole building. They must be combined with other sections or elements to form a structure.
- **Elements** are micro objects, which can make up a vast variety of sections or structures when combined. They allow for the most freedom and creativity.

— **Positioning** concerns how objects are placed in relation to their placement in the virtual world.

- **Grid-based or Floating** concerns whether objects are placed on a fixed, rigid grid or placed freely with floating point positional values (smoothly).
- **Grounded or Elevated** is in relation to whether objects snap to the ground, with a fixed height relative to the terrain or if they can be placed on top of each other with an increasing height value.
- **Physics or No physics** whether gravity is applied to placeable objects or not. Usually visible if objects are placed on top of each other and the bottom object is removed, physics would pull the other objects downwards. This dimension is only valid if the objects can be elevated.
- **Rotations** dictates if players can rotate placeable objects, and if so, on how many axes (1-axis, 2-axis or 3-axis).

— **Resources** is whether the act of placing objects is dependent on resources or not. It does not state what kind of resources placing objects requires or how these resources are gained.

- **Unlimited or limited** is whether placing objects requires no resources, thus is unlimited, or is limited by required resources.

— **Game Flow** has three dimensions, all related to when players can place objects and whether they are under some kind of pressure while placing objects.

- **Unconditional or conditional** states whether there are certain conditions that allow players to place objects (conditional) or not (unconditional).
- **Untimed or timed** is whether there is a timer in the game or not. Usually the timer denotes when the player meets enemies or similar.
- **Real-time or Asynchronous** whether the game progresses while the player is placing objects or not. In real-time the game continues while the player may place objects, while asynchronous means that the player has time to think or wait before placing objects.

In order to show a practical application of the taxonomy, a small example table is presented with four select games in table 1 on page 5.

Example Game	*Age of Empires II (Typical RTS)*	*SimCity 4*	*Minecraft*	*StarForge (Fort Defense Mode)*
Camera Perspective	Orthogonal, Axonometric, No toggle	Perspective, Axonometric, No toggle	Perspective, First Person, Toggle	Perspective, First Person, Toggle
Overview	Mini-map	Mini-map	None	None
Module Scale	Structure	Structure, Section (Zones)	Element	Structure, Element
Positioning	Grid-based, Grounded, None	Grid-based, Grounded, 1-axis	Grid-based, Elevated, No Physics*, None	Grid-based, Elevated, Physics, None
Resources	Limited	Limited	Limited**	Limited
Game Flow	Unconditional, Untimed, Real-Time	Unconditional, Untimed, Real-Time***	Unconditional, Untimed, Real-Time	Unconditional, Timed, Real-Time

Table 1 – ** Except sand blocks. ** Unlimited in Creative Mode. *** Asynchronous when paused. This table shows four selected example games, categorized and classified after the proposed taxonomy. Note that this table could be expanded with virtually any video game.*

These games were selected because they all incorporate some interesting aspect of placing objects. Age of Empires II (Ensemble Studios, Hidden Path, Entertainment (HD Edition), 1999) is a classic for the real time strategy (RTS) genre, and its classification applies roughly to most modern day RTS games as well. However, most modern RTS games no longer use orthogonal camera perspectives and their game flow is often timed, but otherwise the RTS genre has stayed mostly the same. The SimCity (Maxis, 2003) series is perhaps the most popular city building series ever. It provides players an overview with the axonometric camera perspective and the minimap, makes it easy to place objects by providing a grid, and making the structures grounded. The unconditional, untimed game flow is mostly in real-time, unless the player pauses, making the game flow asynchronous as the player can still build. Both Sim City and Age of Empires gives the player an axonometric camera perspective to provide sufficient overview. StarForge (CodeHatch, 2013) is a game currently in alpha (as of April 2013), but videos reveal most of its key details. It has both whole structures and elements, allowing players to build complex, elevated buildings, which still have to be supported physically. Both StarForge and Minecraft (Mojang, 2011) puts the player in first person at default, which seems to reduce the overview, but perhaps makes it easier to combine elements. Both games also allow players to toggle between a few camera types, including the Third Person perspective. Minecraft is possibly the most interesting game to this project, because it is heavily based on the act of placing cubes.

1.5 Survey: Minecraft

One of the most interesting games in the field of placing objects is the widely popular and successful 3D game Minecraft. In order to get a better overview of what makes Minecraft attractive to its players, a survey was conducted among Minecraft players, by using two select online Minecraft forums. The survey was designed as a structured questionnaire, with both quantitative and qualitative questions. The purpose of the survey was to map any general tendencies in the Minecraft community, in relation to what the players actually spend their time on and what they enjoy about Minecraft the most. One of the secondary goals was to examine how many Minecraft players use third party add-ons in order to facilitate the act of placing objects in Minecraft, and why they use add-ons.

1.5.1 Demographics

The first finding from analyzing the results indicate that a very specific demographic group participated in the survey, which is likely caused by the selection of the two Minecraft forums. 49 participants were sampled using a non-probability judgemental sampling method, since the survey had a specific target group - Minecraft players.

The demographics showed that 44 of the 49 were males, and 39 out of 49 were at an age between 13 and 24 years old. 39 of 49 were either Danish or Americans, which can be explained by the fact that one of the Minecraft forums was in Danish and the other was based in the US. The average participant reported playing Minecraft either more than once per day or more than once per week, adding up to 47 of 49 participants in these two groups. 34 of 49 participants reported playing between one and three hours per session. These demographics reveal a very homogenous group, where young gamers make up most of the player base.

1.5.2 Spending Time and Liking it

Five aspects of Minecraft were examined in the survey, by asking participants to rate: a) how much time they spent on that particular Minecraft aspect in percentages, and b) how much they enjoyed or disliked spending time on that particular Minecraft aspect on a 5-point Likert scale. These results were depicted using box plots, as can be seen in figure 2 on page 7.

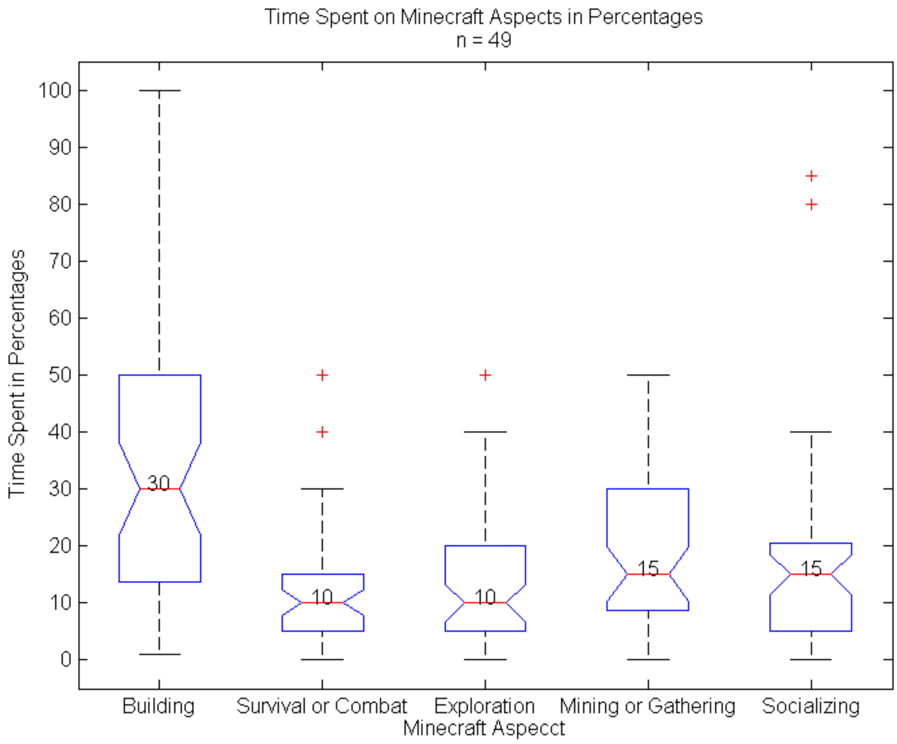

Figure 2 – *A box plot showing the participants' reported time spending in Minecraft.*

This box plot shows how participants reported that they spent their time, in percentages. From the box plot it can be seen that the aspect of building seems to take up most of the participants' Minecraft time, with some participants reporting spending up to as much as 100 % of their time on building. A one-way variance analysis (ANOVA) revealed that the building mean was significantly different from all the other groups. These results can be correlated with participants' answers on how much they disliked or enjoyed the same aspects, as can be seen in figure 3 on page 8.

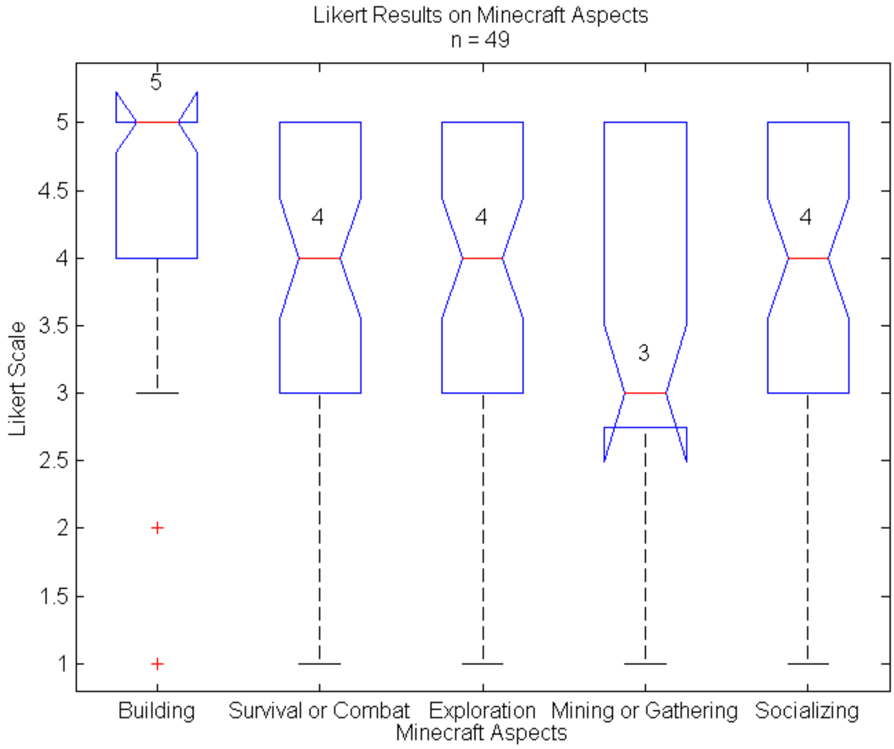

Figure 3 – *A box plot showing the participants' reported enjoyment and disliking of several Minecraft aspects.*

This box plot shows how participants rated the five Minecraft aspects on a 5-point Likert scale, 1 being dislike and 5 being enjoy. The results indicate that participants prefer building, as the building median is one point higher than any of the others, and two points higher than mining or gathering. This is backed up by the fact that all the other groups, except socializing, were significantly different from the building aspect, based on an ANOVA.

By correlating the results from the two box plots, using Pearson's product-moment correlation coefficient, it seems that there is indeed a correlation between what participants spend their time on in Minecraft, and what they actually enjoy. They enjoy building the most, and they spend most time on building. The exception to this generalization is in the case of mining or gathering, which is the aspect that participants rated as the one that took second most of their time, while it was the one which scored lowest on the Likert scale. This is probably due to the design of the game, forcing players to gather or mine (gaining resources) before being able to build (in normal, survival Minecraft mode). The highest correlation was found to be in exploration, with a very low p value at 0.0000758. In the context of this project, the most interesting correlation could be found between participants' time spent on building and their associated Likert scale answers, with a probability value p at 0.0036, well below the 0.05 confidence level.

The qualitative answers indicate that most participants enjoy building in Minecraft, because it allows them to be creative with endless possibilities. This is evident in answers such as: "*You can build anything you want to. The only limit is your imagination...*" and "*Minecraft allows you to build literally everything. That's the main reason for me to keep on building*". Although several participants reported liking the building aspect of

Minecraft considerably, a majority of the participants answered that they used some kind of third party tool to facilitate the act of placing objects, i.e. building, in Minecraft.

1.5.3 Third Party Help

The participants were also asked whether they used any third party tools to facilitate building. The results show that 29 of 49 participants actually did report using some kind of third party add-on. Of those 29, 19 reported that they used their add-on because it provided them with a superior overview, compared to the standard game. 18 reported that it let them modify the terrain more easily, while 15 thought that it made them faster at building by performing several tasks simultaneously. These results could indicate that some participants are not contend with the standard first person camera perspective, and therefore look to third party tools for a better overview.

1.5.4 Minecraft Survey Conclusion

The Minecraft survey showed that the Minecraft players participating in the survey generally like to build in Minecraft, the freedom that the game provides seem to be the main driving factor for many players. Therefore, it seems that the first person camera perspective, used in Minecraft per default, could be a viable starting point for this prototype. Although the fact that many participants use add-ons to help them build raises the question of whether first person perspective truly is the one that would facilitate players' desire to continue building the best. Thus, the next step in this project is to look into how changing the camera perspective affects players' desire to continue placing objects in a 3D environment.

The responses from the Minecraft survey indicate that creativity and freedom are important motivational factors for some Minecraft players. However, Minecraft does not allow players to rotate objects, and it uses a grid to place objects. Therefore, it could be interesting to test on a prototype which offered even more freedom, through floating placement and 3-axis rotations.

2 Camera Perspective Tests

The first testing phase of this project was centered around the camera perspective, as the Minecraft survey revealed that some players try to get a better overview from third party tools. Additionally, the taxonomy showed that some games allow players to change perspectives, often using an axonometric or top-down perspective for overview. The camera tests were meaningful in relation to the problem statement, see 1.1 Motivation on page 1, since the chosen camera perspective has a notable impact on how objects can be placed. The purpose of the camera tests was to reveal if any particular camera perspective would result in a significantly higher or lower desire to continue for players.

As Minecraft allow players to toggle between first- and third person camera perspectives, those two perspectives should be included in the camera tests prototype as scenarios. As the third camera type, the typical RTS perspective, axonometric, was meant to be utilized. The assumption was that the axonometric view would provide a better overview, but it might be harder for participants to actually place objects, compared to first- or third person perspectives. This assumption is based on the fact that placing objects with elevated height (non-grounded) can be troublesome from an axonometric view, as height may be harder to evaluate. A null hypothesis was formulated for the test:

$\mathbf{H_0}$: There is no significant difference in players' continuation desire between different camera perspectives.

2.1 Pilot Test

A pilot test was conducted with 9 participants on the first iteration prototype. It revealed that there was a range of issues with the prototype game, mainly caused by technical, unintended bugs. The pilot also revealed a few issues with some of the questions in the questionnaire. However, and perhaps most importantly, the pilot test made it obvious that the implementation of an axonometric perspective did not work as intended; it was too similar to the third person perspective and the fact that participants were able to pan the camera made the perspective seem more like a third person perspective, only with a higher position (bird's perspective). Additionally, the early results indicated very similar feedback concerning third person and axonometric perspectives. These factors resulted in a decision to remove the axonometric perspective and instead use a top-down camera perspective as the third scenario, as the top-down perspective more closely resembled what the third party tools did to provide players with a better overview in Minecraft. While the pilot test was executed using a between group testing method, it became evident that a within group testing method would allow the survey to ask explicitly which scenario participants personally preferred, granting some possibly interesting supplementary results.

2.2 Setting & Sampling

The tests were conducted in large room with many student groups discussing, listening to music, eating etc. Although the test area was blocked off by semi-walls, noise and smell were factors of annoyance to the test, possibly causing a bias for some participants. Participants were rewarded with soft drinks, juice, snacks or beer after finishing their test, which means that the presence of an extrinsic motivation could result in bias for some participants. They were sampled using a non-probability convenience sampling method. The test was executed as a no-blind test, meaning that participants always knew what camera perspective they were testing.

2.3 Setup

The prototype was designed so that players were able to spawn an unlimited amount of objects, either sections (walls and roofs) or elements (bundles of leaves). Players could pick up earlier placed objects by pressing *e* and they placed currently held objects by clicking the left mouse button. There was no facilitated overview, as the camera test was focused on the inherit overview of the camera perspective. The prototype was designed to be unconditional and untimed in real-time. However, the pilot test revealed that a single condition was needed, due to the participants attempting to build the shelter at the wrong location in the map. Therefore, players were limited to building on the intended side of the map, thereby introducing a single building condition based on position.

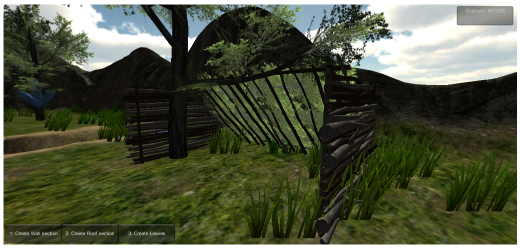

Figure 4 – *This figure shows the prototype shelter which participants were shown and asked to attempt to build ingame.*

In order to make sure that the gathered data was comparable across scenarios, all participants were asked and shown, through a tutorial video, to build a small shelter consisting of two wall sections, two roof sections and a variable amount of leaves (at least three). The shelter can be seen in figure 4 on page 10. However, some participants actively chose to ignore the instructions and wanted, on their own accord, to build something creative or different. These participants were not stopped and were thus allowed to digress from the intended assignment, as the test was more concerned with encouraging players to use the prototype long enough so that they could form an opinion about their prefered camera perspective.

The top-down camera perspective was not implemented in exactly the same way as the others. In top-down perspective, participants could adjust object height with the mouse scroll wheel, a feature not existing in the other perspectives, where the object always followed the player's center of screen. Therefore, there were a few uncontrollable, independent variables especially associated with the top-down camera perspective, which could result in biased data. However, not being able to adjust height in the top-down perspective was considered to cause even more bias, as elevated object placement would be impossible. At the end of each scenario, the test observers noted down in the questionnaire whether the participant had completed the intended shelter in that scenario. Observations indicate that some participants might have noticed this behaviour and were thus possibly affected by seeing that they did or did not complete the assignment, possibly causing a behavioural change in subsequent scenarios.

In the camera perspectives test the questionnaire was made with Google Docs' Form application, which does not inherently facilitate Likert scales with custom ranges, and limits scales to a range of 0 to 10. However, the ESQ framework makes use of a 7-point Likert scale which ranges from -3 to +3 (Schoenau-Fog et al., 2012). This point was disregarded in the camera perspectives test, where a 1 - 7 range was used.

2.4 Demographics

The demographics confirmed an expected bias caused by the very homogenous group of testing participants. 29 of 30 participants were between the ages of 19 and 26 years, and 90 % (or 27 of 30) were males. The demographic findings also indicate that a vast majority of participants were gamers, meaning that they relatively often play video games. 25 of 30 participants reported playing video games more than once per week or even more than once per day, while 21 of 30 reported spending more than 2 or even 4 hours per playing session. These results strongly indicate that the participants were predisposed to like games. Additionally, they had experience with how games generally work, and they had the muscle memory to actually control the game fluently[2]. Observations from the test confirmed that gamers were generally better at playtesting the prototype and as a result often reported a higher continuation desire, compared to the non-gamers, who struggled more interacting with the prototype. When asked about prior experience with placing objects in games, 20 of 30 participants rated their own experience as above average, 5 to 7 on a 7-point Likert scale, further reinforcing the impression that the majority of participants were experienced gamers.

2.5 Continuation Desire Results

The most interesting result from the camera tests was the comparison of the three camera perspectives, captured in figure 5 on page 12.

[2]The prototype game made use of movement control conventions, such as *w* (forward), *a* (left), *s* (backwards) and d (right) for movement, *space* for jumping and *e* for interaction with objects.

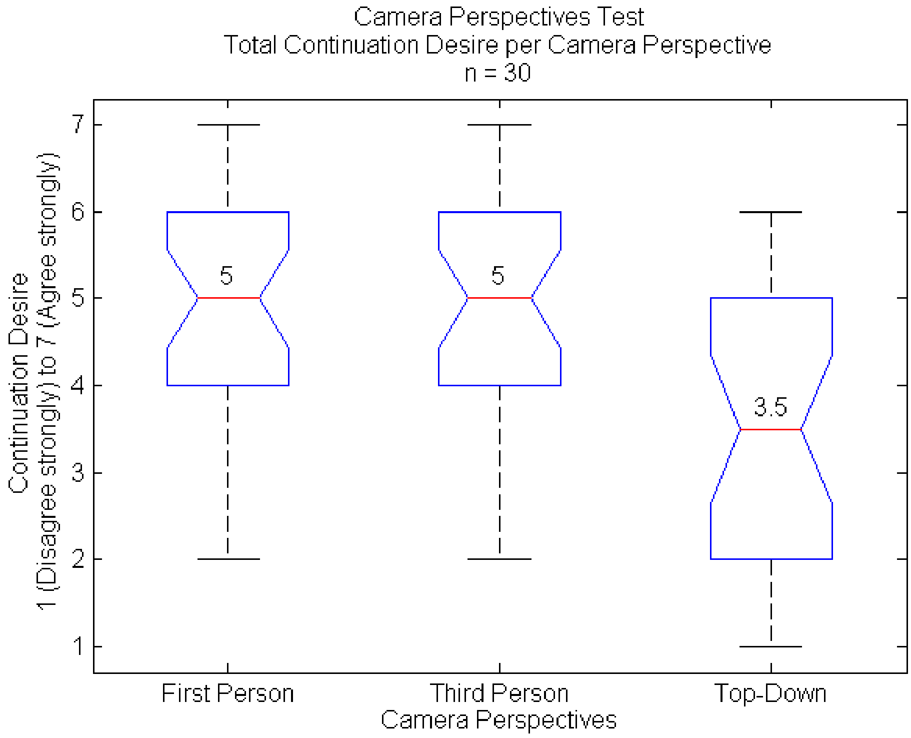

Figure 5 – *This box plot shows the reported continuation desire divided on camera perspectives.*

By executing an ANOVA test, a significant difference was found in continuation desire between first person and top-down camera perspectives, as well as between third person and top-down, thus the null hypothesis H_0, see 2 Camera Perspective Tests on page 9, can be rejected. The results indicate that there is no difference between first- and third- person camera perspectives in medians, although the first person perspective mean was slightly above that of third person perspective. In addition to using continuation desire to indicate what scenario players prefer, participants were also asked explicitly at the end of each test, which scenario they personally preferred.

2.6 Preference

The preference results from the participants reveal a large majority, who reported preferring the first person perspective. 16 of 30 participants chose the first person perspective as their prefered one, while 8 of 30 participants chose third person perspective, and the remaining 6 participants chose top-down as their preferred perspective. These results can be seen in figure 6 on page 13.

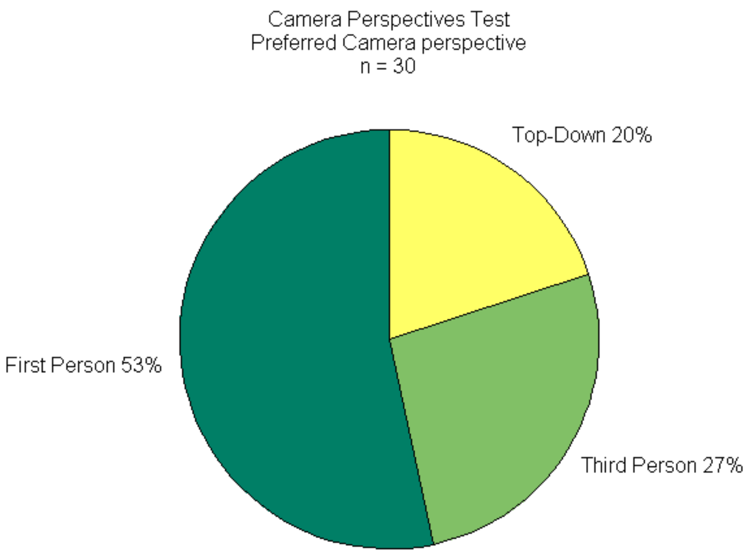

Figure 6 – *This pie chart shows what camera perspectives the participants chose as their preferred, after trying them all.*

Qualitative answers also indicate that many participants prefered the first person perspective, with comments such as: "*First person gives the most free orientation options and also is more appealing to my eyes.*", "*Well it's much easier to get the 3 dimensional feel of the scene [in first person perspective].*" and "*easier to determine relative position of objects in regards to height and distance between object and player [in first person perspective]*". Therefore, as the first person perspective showed the highest mean continuation desire and was also the most prefered one, based on an explicit question, it was decided to progress with the first person camera perspective in further iterations.

2.7 Camera Tests Conclusion

The main conclusion from the camera tests was that a top-down camera perspective was the worst implementation included. First and third person were almost equal, and as such one of those two perspectives should be used in further iterations. Since first person perspective was the most preferred camera perspective, it was decided to proceed with the first person camera perspective for further iterations.

Observations and verbal feedback from the camera tests suggest that some participants disliked the rotation scheme, e.g. the way that buttons were mapped. Qualitative answers such as: "*It was a bit annoying that you have to rotate the objects by using the numpad. Especially when you use WASD and the mouse [to move the character,] you have to move your hand to rotate.*" and "*Mouse controls felt a bit odd*" indicate that there were difficulties with the mapping. In the camera tests prototype there was no emphasis on the rotation scheme, only its consistency across camera perspectives. Therefore, the next interesting step for this project was to look into rotation schemes and the use of a mouse or keyboard, for rotating and placing objects.

3 Rotation Scheme Tests

The purpose of this second iteration test (henceforth referred to as rotation scheme tests) was to examine what kind of rotation scheme afforded the highest desire to continue for players. It was very meaningful in relation to the problem statement, stated in 1.1 Motivation on page 1, since the rotation of an object has an obvious impact on the placement of the object. One of the most mentioned points in the camera tests, was that a forced hand movement in order to rotate objects was undesirable for most participants. Based on the feedback from the camera perspectives test, there seems to be two independent variables of particular interest to this project. The first variable being the input device used to rotate objects, namely the keyboard or mouse, while the other independent variable was the forced hand movement.

3.1 Setup

In order to avoid having to design a test robust enough to actually encompass two independent variables simultaneously, it was decided to execute two separate tests in quick succession, with each their own version of the prototype game. The prototypes used for the rotation tests was a further iteration from the camera perspectives prototype, which was discussed in 2 Camera Perspective Tests on page 9. The main purpose of the rotation tests was to examine whether an implementation based mainly on the keyboard or one mainly based on the mouse would be preferable for the majority. Additionally, the secondary purpose would be to examine the effect of forcing physical hand movement. Both versions compared two rotation schemes: one mainly based on the mouse, against another rotation scheme mainly based on the keyboard.

The first version which enforced a physical moving of one of the hands was named 'Version A', while the other version not forcing a hand movement was named 'Version B'. Four mapping schemes were designed, two for each version, as shown in table 2 on page 14.

	Mouse		**Keyboard**	
	Modifier	*Rotation*	*Modifier*	*Rotation*
Version A - With forced hand movement	Numpad keys: 4 or 6, 2 or 8, 7 or 9	Mouse dragging (click and move)	None	Numpad keys: 4 or 6, 2 or 8, 7 or 9
Version B - Without forced hand movement	Ctrl, alt, shift	Mouse dragging (click and move)	Ctrl, alt, shift	W, A, S and D

Table 2 – *This table shows a complete overview of all the rotation schemes designed and implemented for the rotation scheme tests.*

These mapping schemes were designed with minimizing independent variables and favourable conditions in mind. Even though none of the mapping schemes were expected to be the 'best' scheme from an objective point of view, they were assumed to be objectively equally good, in an attempt to make them as comparable as possible. However, through the design process it seemed hard to come up with a single mapping scheme which did not afford favourable conditions in one direction. The forced hand movement scheme was assumed to be favourable towards the keyboard, since it did not require modifier keys. The scheme without forced hand movement was assumed to be favourable towards the mouse, since double mapping the WASD keys, which were already used to move the character, was expected to be a negative influence.

As mentioned earlier in conjunction with the camera perspectives test, see 2.3 Setup on page 10, the 7-point Likert scale ranged from 1 to 7. However, it makes sense to use a range from -3 to +3, because it is more intuitive to represent a negative continuation desire with negative numbers, compared to a Likert scale ranging from 1 to 7. For this reason, and the point that 'tabbing out' of the game is just annoying in itself and requires careful observations to ensure that participants do indeed answer the questionnaire at the right moment, time was spent on implementing an integrated (in-game) questionnaire for the rotation schemes tests

3.2 Version A - With Forced Hand Movement

The version A rotation schemes can be found in table 2 on page 14. As the main purpose of the version A tests was to see if the continuation desire means of the two rotation schemes would be different, the null hypothesis was:

$\mathbf{H_1}$: There is no significant difference in players' continuation desire in version A between a mainly mouse-based rotation scheme and a mainly keyboard-based rotation scheme.

3.2.1 Setting & Sampling

The setting for the rotation scheme tests of version A were very similar to the setting of the camera perspectives tests, explained in 2.2 Setting & Sampling on page 10. Approximately a third of the tests were conducted in the exact same environment as was the case for the camera perspectives test. The other two thirds of the participants tested in a closed room, limiting some of the annoyances from noise, smells, etc.

The sampling method was equal to the camera perspectives test, as already explained in 2.2 Setting & Sampling on page 10.

3.2.2 Demographics

The demographics confirmed the expectation that the participants would be relatively homogenous, as was also the case in 2.4 Demographics on page 11. All participants were between the ages of 15 and 29 years, while 22 of the 30 were between 20 and 24 years old. A total of 93.33 % (or 28 of 30 participants) were male. Most of the participants were gamers who play regularly , with 25 of 30 participants playing video games either more than once per week or even more than once per day. 22 of 30 participants reported playing either more than two hours per session, or more than four hours per session. 24 of 30 participants reported that their experience with building in games was positive, on a 7-point Likert scale ranging from -3 to +3, with 16 participants either reporting a +2 or a +3 on experience with building in games. These demographic results all confirm the expectation of a homogenous population of test participants, giving rise to obvious bias.

3.2.3 Continuation Desire Results

After each rotation scheme participants were asked to rate how much they would like to use that rotation scheme on a 7-point Likert scale ranging from -3 to +3. The results revealed that the two rotation schemes had the exact same median on the continuation desire scale. By executing a t-test, it was found that the means of the mouse and keyboard schemes were not significantly different. Thus, the null hypothesis H_1, see 3.2 Version A - With Forced Hand Movement on page 15, failed to be rejected. The only difference seems to be that the mouse rotation scheme was slightly less disliked, as can be seen by the minimum whisker at -2 for the mouse scheme, while it is at -3 for the keyboard scheme. This point can also be seen in figure 7 on page 16.

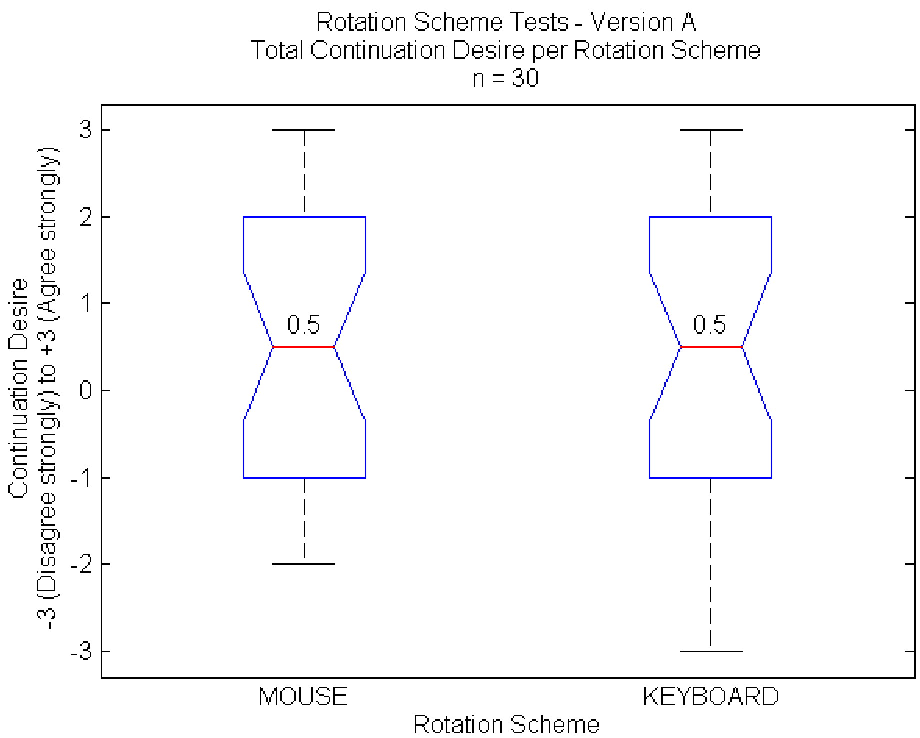

Figure 7 – *This box plot shows the participants' reported continuation desire in version A, divided on rotation schemes.*

3.2.4 Preference

As the final question participants were asked explicitly which rotation scheme they preferred. The results would indicate on a qualitative level which rotation scheme participants generally liked the most. The results however indicate that neither of the rotation schemes were significantly preferred. This can also be seen in figure 8 on page 17. The split preference is also evident in qualitative responses, with some participants calling the keyboard scheme intuitive while others called the mouse intuitive, as can be seen through responses such as: "*The controls made it a lot easier to build the assignment asked, and made it more intuitive to play the game itself [in mouse scheme]*" and "*This [keyboard scheme], to me is a much more intuitive way of building, than when using the mouse. (...)*".

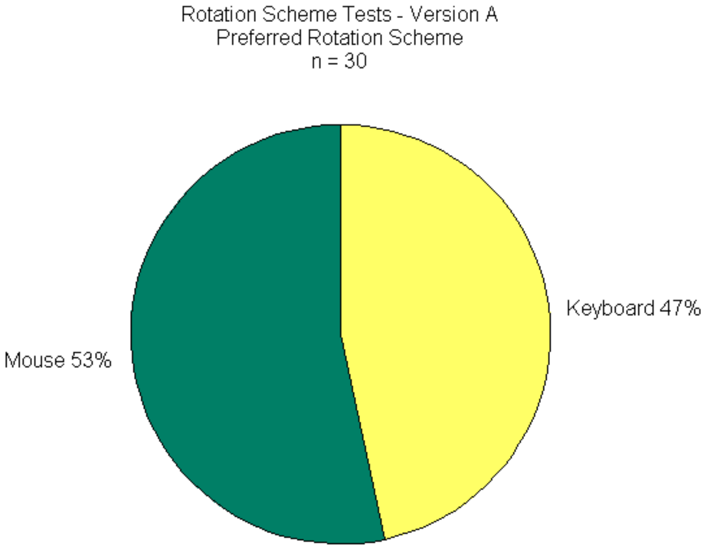

Figure 8 – *This pie chart shows what rotation schemes the test participants preferred.*

3.3 Version B - Without Forced Hand Movement

The second pair of rotation schemes for version B, as explained in 3 Rotation Scheme Tests on page 13, are shown in table 2 on page 14. This meant that these keys were actually double-mapped, or one-to-two mapped, since the same keys were also used for moving the character. To avoid moving the character while trying to rotate, character movement was prohibited while holding down any of the modifier keys in both versions. The main purpose of the version B test was to see if the continuation desire means of the two implemented rotation schemes would be significantly different, thus the null hypothesis was formulated as:

H_2 : There is no significant difference in players' continuation desire in version B between a mainly mouse-based rotation scheme and a mainly keyboard-based rotation scheme.

3.3.1 Setting & Sampling

The setting for version B was divided into two parts. Approximately a third of the participants were tested in the exact same setting as in the camera perspectives, as explained in 2 Camera Perspective Tests on page 9. However, the other two thirds tested the prototype game on their own computers, wherever they wanted. The version B test was distributed through social media, making it possible for family, friends and acquaintances to test the prototype.

The sampling method for those participants found at Aalborg University Copenhagen was once again a non-probability convenience sampling method, as was the case for the camera perspectives test, explained in 2.2 Setting & Sampling on page 10. However, some of the participants found through social media were to some extent gathered through a non-probability snowball sampling method, as in several cases it was actually friends of friends who tested. It could be said that the sampling method used in version B was to some extent judgemental, as friends who play games regularly, and who were expected to have an interest in playtesting a prototype game, were asked personally to test. This mixed sampling method was expected to result in a slightly less homogenous participant group demographically, compared to earlier tests.

3.3.2 Demographics

The demographic result from the version B tests confirmed the expectation that the tested population would again be relatively homogenous, albeit slightly less than in previous tests. 31 of 33 participants were between the ages of 15 and 29, with 17 of 33 participants being in the interval between 20 and 24 years old. 29 of 33 of the participants were male. 31 of 33 participants reported playing video games either more than once per week or more than once per day. 14 of 33 participants reported playing more than two hours per session, while 6 of 33 participants responded playing more than 4 hours per session, and another 6 of 33 reported playing more than 6 hours per session. 5 of 33 participants stated that they played more than 1 hour per session. The experience with building in games revealed a slightly more varied group compared to earlier tests, with 22 of 33 participants choosing one of the positive values, and 10 of 33 participants choosing one of the negative values. The group of participants were still quite homogenous, consisting of young adult, males.

3.3.3 Continuation Desire Results

The continuation desire results, gathered after playtesting each scenario, indicated that the medians of the two rotation schemes in version B were equal on the continuation desire scale. A t-test was executed on the two groups and concluded that the means of the mouse and keyboard schemes were not significantly different. Thus, the null hypothesis H_2, see 3.3 Version B - Without Forced Hand Movement on page 17, failed to be rejected. The results from the two rotation schemes in version B were equal, as can also be seen in figure 9 on page 18.

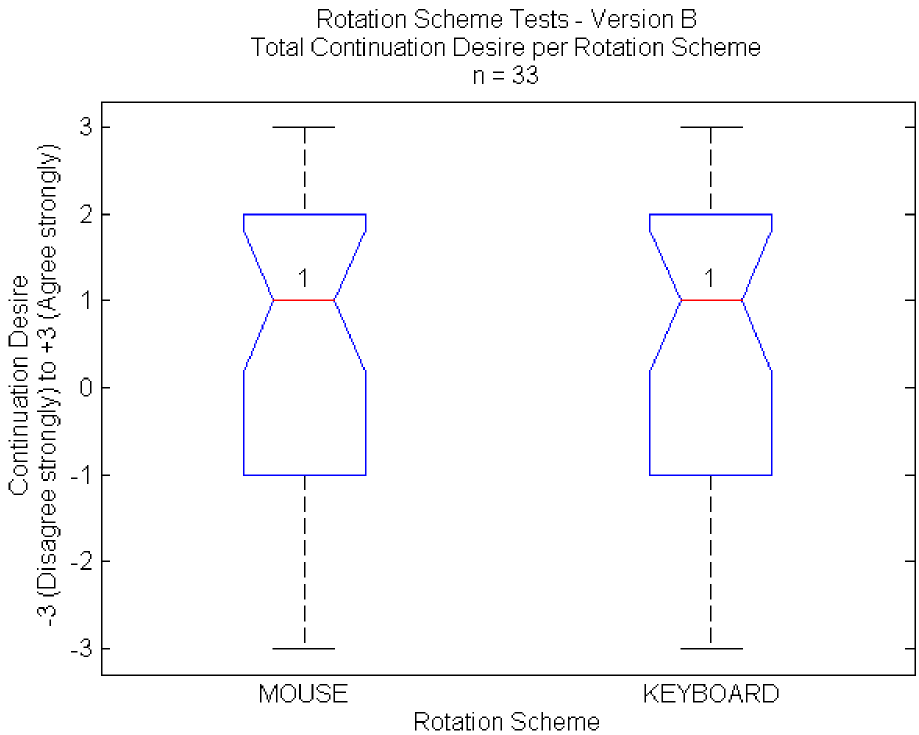

Figure 9 – *This box plot shows the participants' reported continuation desire divided on rotation schemes, in version B.*

As could be seen from the quantitative results, some participants liked the mouse while others liked the keyboard. This was also revealed by qualitative responses such as: "*Trying to get items to be completely orthogonal to you view is kinda weird, otherwise it works great. [in mouse scheme]*" and "*I feel like I have the controls to change everything I want however I want it [in keyboard scheme]*".

Several participants noted that they disliked having to hold down left mouse button (dragging) to rotate objects, and suggested using the mouse movement while holding down the modifier keys, without the necessity of left clicking. Responses such as: "*(...) Just felt wrong to hold both a keyboard button and a mouse button to rotate [in mouse scheme]*" and "*This [mouse scheme] is a bit better, but I hate the modifier being alt, ctrl, shift. That does not provide a resting hand position, and it could be done just as easily with using the mouse buttons.*" indicate that this was an issue for some participants.

3.3.4 Preference

The preference results were used as a qualitative supplement to the more quantitative continuation desire results. The preference results in version B indicated a large majority of participants who reported preferring the mouse rotation scheme, with two thirds or 22 of 33 participants choosing the mouse rotation scheme as their preferred one. This can also be seen in figure 10 on page 19.

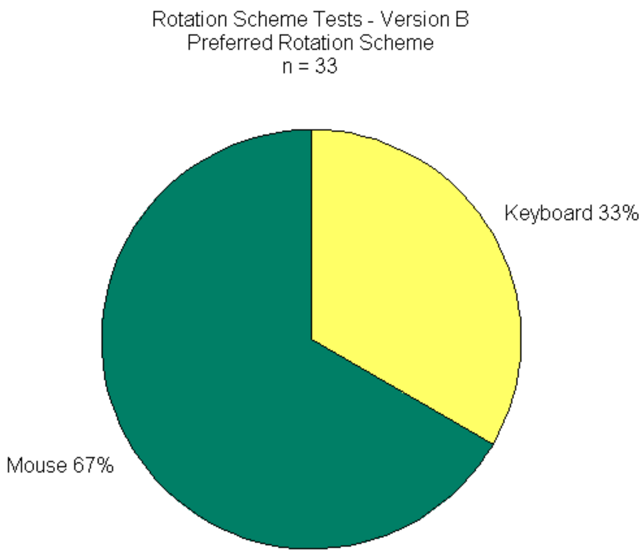

Figure 10 – *This pie chart shows which rotation scheme participants chose as their preferred, in version B.*

The qualitative responses backs up that most participants preferred the mouse scheme, with participant statements such as: "*It is so much easier to adjust to using 2 hands for 2 jobs than using 1 hand for 2... and it feel a lot more smooth [in mouse scheme]*", "*Mouse is so much more fun to build with.*" and "*Changing the hold button can be quite annoying but I suppose it's a question about getting used to it. The mouse interaction way is probably the far best in my opinion. It feels more natural*". Even though a few participants still reported preferring the keyboard scheme, with responses such as: "*It seems* *more fluent using the keyboard for positioning spawning and rotating and then the mouse for specific placement. You don't move and rotate at the same time, but you do rotate and position the elements at the same time. [in keyboard scheme]*" and "*Easy control when turning the objects in any way you want [in keyboard scheme]*".

3.4 Rotation Schemes Conclusion

Even though it was expected that there would be significant differences identified through the rotation scheme tests, t-tests found that all the null hypotheses failed to be rejected. The continuation desire results indicate that most participants did not perceive any major differences in how much they wanted to use each rotation scheme, causing them to rate the two schemes relatively equal. In version A there was an expected favourable condition towards the keyboard scheme, which means that the slight preference towards the mouse rotation scheme could possibly have been larger, had there not been the presence of a favourable condition. In version B the expected favourable condition towards mouse scheme seems to be evident in the preference results. It could also be stipulated that the sampling size was not large enough, or that another sampling method might provide different results.

3.5 The Effect of Forced Hand Movement

As earlier mentioned in 3 Rotation Scheme Tests on page 13, the secondary purpose of the rotation scheme tests was to uncover the effect of forcing participants to move their hand. Version B served as the control group, while version A was considered the 'treatment', which included forced hand movement. Therefore, the following null hypothesis was formulated:

H_3 : There is no significant difference in players' continuation desire between a version forcing hand movement (A) and a version not forcing hand movement (B).

This hypothesis was tested by compositing the continuation desire results from the two rotation schemes in both versions and comparing the results. Thereby, a comparison of the two versions was possible, where version A included the forced hand movement and version B did not.

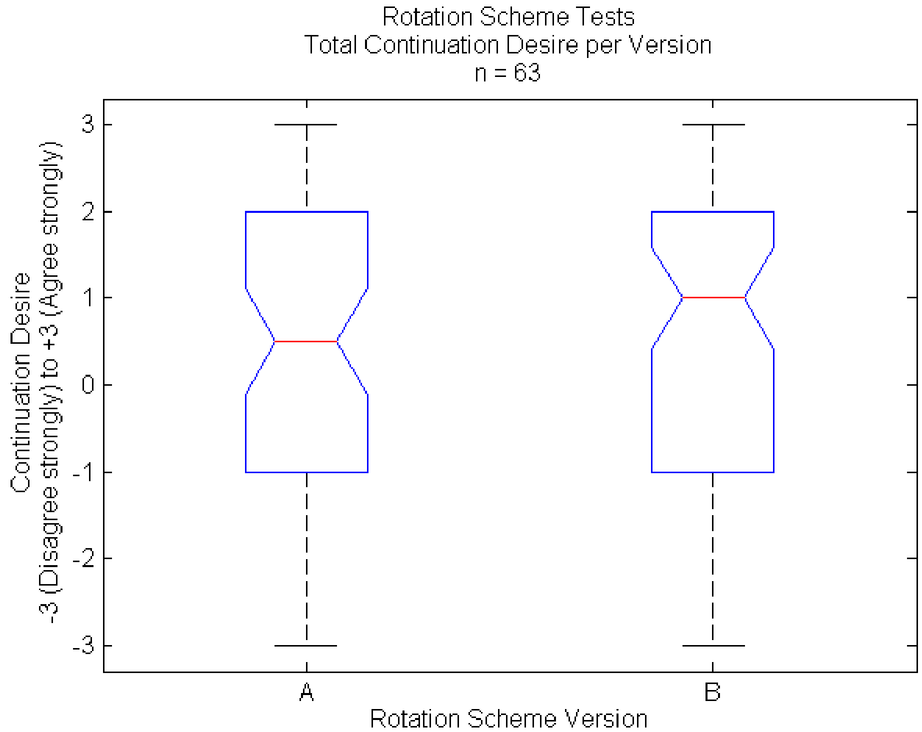

Figure 11 – *This box plot shows the composited continuation desire results from each of the two versions.*

As the box plot, in figure 11 on page 21, also indicates, a t-test revealed that there was no significant difference between the means of the two versions, which means that the null hypothesis H_3, see 3.5 The Effect of Forced Hand Movement on page 20, failed to be rejected. Therefore, this project cannot conclude whether forced hand movement is significantly worse or better. However, the qualitative feedback from version A indicated that the forced hand movement was annoying to some participants, as stated by one participant after using the keyboard scheme: "*I think its irritating to have to move the hand from the left of the keyboard all the way to the right of the keyboard just to make the object move.*" or as another participant stated: "*it is annoying to shift between wasd and numpad with my left hand*". This perhaps indicates that some participants perceived it as undesirable to move the hand to rotate or place objects, while others did not mind it considerably.

The results could also be affected by the fact that participants unknowingly compare the two rotation schemes within each version, meaning that even if they disliked both rotation schemes in version A, they could still have rated one of them +2 or +3, because they perceived it to be better than the other. This warrants a dedicated test on the effect of forced hand movement.

4 Discussion: Data Integrity

In order to evaluate the integrity or validity of the gathered data in this project, the test and its possible issues or flaws were discussed. These issues or flaws were mainly related to the rotation scheme tests, although most apply to the camera perspectives test as well.

4.1 Bias

As already mentioned, all datasets gathered in conjunction with this project are influenced by bias. The perhaps most obvious bias was caused by the demographics, which in turn was caused by the setting and sampling. Due to the homogenous group of test participants the data cannot be generalized to other populations than those sharing similar demographic attributes.

Many other bias were however present, some caused by technical issues. Several participants were unhappy with the implementation of picking up objects, which would sometimes pick up an unexpected object and therefore ruin their shelter or building. Ideally the shader or color on the currently selectable object should have been changed, to indicate which object would be picked up. Some participants experienced issues with the physics system, which occasionally caused leaves or other objects to hover in the air for several seconds before the object would drop to the ground. Some participants had to use the in-game 'Fix Bugs' button, found in the main menu, when an object would always be unplaceable. A few participants experienced 'flying' in the map, caused by picking up and simultaneously stepping on an object already lying on the ground.

Another bias was caused by the fact that a tutorial video was utilized as an introductory method to the assignment, due to the fact that observations indicated that some participants did not pay proper attention to the video and therefore needed to watch the tutorials again. Additionally, different learning styles could mean that some participants did not learn the controls properly through the tutorial video. Another possible way to teach the controls would be an in-game training session (or in-game tutorial), which was expected to facilitate learning the controls better than a tutorial video for some participants, presumably mostly the non-gamer participants. However, regardless of the introduction method, bias would still have been present.

Observations indicated that some participants were affected by the fact that two participants were testing simultaneously. When one participant finished the test, the other participant often seemed to finish rather quickly afterwards as well, even though he did not spend as much time on the last scenario. This was believed to introduce some bias to the data, since some participants did not get a complete overview of the last scenario, or did not pay proper attention to the final questions.

4.2 Ergonomics

Through observations and the qualitative responses, it seems that the physical placement of the test participants' hands was an important factor. A few participants directly noted that the forced hand movement in version A meant that the hands needed to be placed in a somewhat awkward position ergonomically. A few other participants noted that the double mapping in version B, especially in the keyboard rotation scheme, meant that the left hand was placed uncomfortably. Therefore, it could be stipulated that ergonomics is an important factor to consider when designing control schemes for placing and interacting with objects.

4.3 Favourable Conditions

As mentioned earlier in 3.1 Setup on page 14, favourable conditions were present in the two versions of the rotation scheme tests. These favourable conditions include that the keyboard rotation scheme in version A did not incorporate modifier keys, making it objectively easier, due to the need for pressing less buttons than in the other rotation schemes. This means that version A was expected to be favourable towards its keyboard rotation scheme. Therefore, the results indicating that the two rotation schemes were equal could actually mean that the mouse rotation scheme would have been significantly preferred, had it not been influenced by the favourable condition towards the keyboard scheme.

In version B the double mapping on the WASD keys in the keyboard rotation scheme was expected to be a favourable condition towards the mouse rotation scheme, since it did not incorporate as much double mapping. The favourable condition towards the mouse scheme probably affected the participants' preference and perhaps contributed to the fact that a large majority chose the mouse scheme as their preferred rotation scheme. It could therefore be stipulated that had version B not been favourable towards the mouse scheme, the preference results would have been more equally divided.

In all four rotation schemes, the method of picking up and placing objects was consistent. Objects could be picked up by pressing the 'E' key, and placed again by using the left mouse button. This meant that the mouse rotation schemes also had double mapping, since both mouse rotation schemes required participants to click and drag with the left mouse button, which occasionally caused participants to place an object instead of rotating it. This could be said to be a favourable condition towards both keyboard schemes, since the left mouse button was single-mapped in the keyboard rotation schemes.

4.4 Independent Variables

Even though great emphasis was placed with attempting to eliminate or minimizing independent variables between the two versions, and between the two rotation schemes in each version, there was at least one significant independent variable present.

In both mouse rotation schemes, the test participants had more precise control over the rotation of objects, as also noted by a few participants. One participant wrote: "*the lack of precision when trying to place elements was annoying [in keyboard scheme]*", while another participant responded: "*Rotating is too difficult to be precise [in keyboard scheme]*" By controlling the speed of mouse movements, the speed of rotation could be harnessed effectively. This was not possible in either of the keyboard rotation schemes, which used a fixed rotation speed. This meant that the keyboard scheme was in some cases perceived as easier, but less accurate, as one participant put it: "*(...) The keyboard scheme is faster and easier to use than the mouse scheme, but the mouse scheme is more accurate. (...)*".

This independent variable was caused by the nature of the two input devices used. The mouse is grants an analog-style input[3] in nature and therefore can be used to gather floating (or non-fixed) values, by using the mouse speed (or actually the distance moved over time) as a factor. A digital-style input device, such as the common keyboard, does not afford the same floating values, and is always either 'on' or 'off'.

4.5 Fusing Usability & Continuation Desire

As explained in 1.3 Experimental Design on page 2, this project utilized a permutation of the continuation desire framework, by fusing it with usability testing. However, the test was still considered to resemble continuation desire more than usability testing. The one exception being the Likert scale questions, which approached usability testing more than the continuation desire framework, due to the removal of the word 'continue'. The reason for this was that it was considered to be confusing to ask participants if they would "*want to continue playing*", since it would give them the impression that they should consider the whole prototype game in their answer, when they should only be considering the camera perspective or rotation scheme, disregarding the 'rest' of the game. Additionally, the word continue might give the impression that the prototype would allow them to actually continue in the same scenario, when in fact it did not. However, in hindsight the questions could probably have been closer to continuation desire, e.g. by being formulated as: "*Please indicate the extent to which you agree or disagree with this sentence: "I would like to continue using this [implementation], in a*

[3] Analog and digital terms should be understood in an electronics context.

complete game"'. Such a formulation could still be misinterpreted by some participants, but might be closer to the continuation desire framework.

4.6 Comparability of Tests

One of the important considerations when designing and developing the rotation scheme tests and the two prototypes was to ensure as high comparability between the two versions as possible. This would allow for a credible comparison of the two versions, in order to estimate the effect of forced hand movement. However, there were a few factors which decreased the comparability between the two versions.

One of these factors was caused by the fact that character movement was disallowed while rotating in version B. Movement had to be disabled in version B, because of the keyboard scheme utilizing the movement keys for rotating. For consistency between the two rotation schemes, movement was therefore disabled in version B while rotating. However, this was not the case for version A, where there was no obvious reason to disallow movement. The forced hand movement in version A made it impractical to attempt to move the character while rotating. Additionally, an attempt to do so would result in the object not following fluently, but instead jumping in intervals, making this kind of behaviour practically useless. Thus, this point was not expected to cause any significant influence on the data. Regardless, for consistency, movement should have been disabled while rotating in both versions.

As already mentioned as an independent variable, the keyboard rotation scheme in version A did not make use of modifier keys, which was otherwise the case for the three other rotation schemes. From a usability design point of view, it was completely redundant to force the use of modifier keys for the keyboard rotation scheme in version A. However, from an experimental design point of view, modifier keys should have been enforced consistently across all rotation schemes to ensure comparability across rotation schemes and versions.

5 Conclusion

The problem statement for this project, found in 1.1 Motivation on page 1, was formulated as:

In which ways can virtual objects be placed in real-time in a 3D game, and how will these influence players' desire to continue placing objects?

The problem statement set the foundation for the four hypotheses utilized through the two testing phases. The hypotheses were used as a way to evaluate the quantitative results.

The first null hypothesis, written in 2 Camera Perspective Tests on page 9, was formulated as:

H_0 : There are no significant differences in players' continuation desire between different camera perspectives.

The test included three different camera perspectives: first person, third person and a top-down perspective. Through a one-way variance analysis (ANOVA), it was possible to reject the null hypothesis for the comparison between first person and top-down, as well as between third person and top-down. Thereby, based on the results, it seems that the top-down camera perspective resulted in the lowest participant continuation desire among the tested camera perspectives. The supplementary preference results indicated that most participants quantitatively preferred the first person perspective, which was the one used in the following testing phase.

The rotation scheme tests encompassed two separate prototypes (version A and B), each with their own rotation schemes. The prototype which forced a physical movement of the hands in both rotation schemes was named 'Version A' and the hypothesis formulated, see 3.2 Version A - With Forced Hand Movement on page 15, for the test associated with the version A prototype was:

H_1 : There is no significant difference in players' continuation desire in version A between a mainly mouse-based rotation scheme and a mainly keyboard-based rotation scheme.

A t-test executed on the continuation desire results from the version A test indicated that there was no significant difference between the two rotation schemes. The qualitative preference responses from version A confirmed that the two rotation schemes were perceived to be almost equal.

For the version B prototype without forced hand movement, the null hypothesis, found in 3.3 Version B - Without Forced Hand Movement on page 17, was formulated as:

H_2 : There is no significant difference in players' continuation desire in version B between a mainly mouse-based rotation scheme and a mainly keyboard-based rotation scheme.

A t-test executed on the participants' reported continuation desire in version B indicated that there was no significant difference between its two rotation schemes. Thereby, neither of the two versions indicated that there were any significant differences between the two pairs of rotation schemes. However, the preference responses from version B indicated that two thirds of the participants preferred the mainly mouse-based rotation scheme.

A final hypothesis was formulated to enable a comparison of the two versions, in order to indicate whether the effect of forcing physical hand movement was significant or not. The final null hypothesis, see 3.5 The Effect of Forced Hand Movement on page 20, was:

H_3 : There is no significant difference in players' continuation desire between a version forcing hand movement (A) and a version not forcing hand movement (B).

Even though the rotation scheme tests were not optimal for a comparison of the two versions, a t-test was executed by grouping the responses from the two rotation schemes in each version. The t-test indicated that there was no significant difference between the two versions. However, qualitative responses from both versions revealed that some participants did indeed dislike the forced hand movement, even though the continuation desire results did not confirm it.

6 Future Perspectives

Since most of the tests revealed no significant differences, apart from the camera perspectives test, the next logical step for this project would have been to iterate the prototype game and conduct further rotation scheme testing.

Another obvious step would be to setup a proper forced hand movement test, in order to evaluate whether forced physical hand movement would indeed cause a significant effect. A possible reason for why there seemingly was no significant effect, apart from the imperfect comparability of the versions, was due to the context in which participants were asked to build a shelter in the prototype game. It could be stipulated that had participants been under time pressure, be it by the influence of in-game enemies, other players or simply a visual timer, the effect of physically moving the hand would have been more evident, due to the simple fact that moving the hand takes time. Participants would presumably have sought the quickest solution had they been under time pressure, which would probably have been a more realistic case in a real game. Therefore, a next forced hand movement test could perhaps include some kind of time pressure.

It was expected that a mainly mouse-based rotation scheme would be superior for most participants, compared to a mainly keyboard-based scheme. Even though none of the continuation desire results could confirm this expectation, some of the qualitative responses and one of the preference results did indicate that this expectation was perhaps not completely wrong. An informal comparison of the participants' demographics, namely their computer gaming habits, and their preferred choice, seems to indicate that most of the gamers preferred the mouse schemes, while most of the participants not used to play games often preferred the keyboard scheme for its simplicity. Thus, it could be stipulated that testing several mouse rotation schemes against each other could be another viable future step for a further iteration of this project.

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