A STUDY ON DESIGN TECHNIQUES FOR GAME DESIGNERS : reating design techniques through challenge design, narrative and visual contrasts

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A STUDY ON DESIGN TECHNIQUES FOR GAME DESIGNERS

Creating design techniques through challenge design, narrative and visual contrasts

ゲームデザインのためのデザイン手法に関する研究
チャレンジデザイン、ナラティブ、視覚コントラストを用いたデザイン技法の創出

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1. ABSTRACT

Over the years, games have grown exponentially. Not only in terms of popularity, but due to rapid evolution of game technology, games have gone from their simple origins to giant multimedia productions. Due to this, it is now necessary that games composite their content, in order to keep them from becoming confusing. For our research, we addressed three areas; challenge design, narrative and visual perception, for the sake of creating methods to effectively design modern games.

For challenge, we argued that current day challenge definitions were faulty as they didn't properly encompass all forms of challenge. For that we analyzed challenge trends within game design and came to five categories. We continued by researching how a proper challenge should be designed to apply to our found categories and created six design heuristics by which a proper challenge should abide. We also were able to report particular player habits when it comes to challenge, so that future designers can take this into account to enrich their challenge design in games.

For narrative, we addressed how to design visual worlds and make them able to confer information to the player. For this, we analyzed existing game software and created a set of elements that can be used for creating game worlds with narrative content. We further validated these elements through our experiments and found that using these elements had a positive effect on the users' immersion levels, proving their effectiveness.

Our visual perception research was geared towards making navigation in games more accessible to users, as an extension to our narrative research. We found that especially inexperienced users had trouble navigating modern games. We attempted to use colors in order to influence the users' viewing behavior and their decision making. We analyzed two aspects; color contrasts and color luminance. For the contrasts we used Johannes Itten's contrasts, but found that contrasts have no significant effects whatsoever. For our luminance research, we found that areas surrounding "goals" as perceived by the user were more looked at when the luminance

contrast values were high, indicating that luminance contrasts are useful as visual cue.

In conclusion, the methods gained through the research we conducted will certainly enable designers to create more effective game design, making sure that even as game technology evolves even further, the designer is prepared for it. Furthermore, through this research we will also be able to understand games better, opening opportunities for further research into game design.

2. BACKGROUND

2.1Why is Design Knowledge Necessary

I come from a design background. As early as college I was involved in game design related jobs, both in terms of graphic design as well as interaction design. During my master course in the Netherlands at the Utrecht School of the Arts, I further specialized myself in game design.

It was during this course that I realized that even though game design has been around for around 30 years now, there is still very much we don't know about it. During the classes that had game design as its theme, rather than learning what made good design, we instead focused on how to write so-called design documents (documentation that has as aim to explain all the mechanics of a particular game, so other development divisions such as programmers can use it to construct the game itself) as well as the themes that would generally appear within those documents. Other game design classes would concentrate on moral issues on game design as well as the philosophical side of game design. None of those classes taught us anything about what made for good game design. During my final year at this university, we had to do a cooperative project with people from fields outside of our own game design field. These people had generally very little to no experience designing a game, and they were making many of the same mistakes that we were during our earlier years in the course. This made me realize that the game design field, as it is now, is essentially a field based on trial and error.

This further continued after graduation, when I entered the industry as a game design professional. As there was a necessity to design games for target audiences and game genres I was unfamiliar with, I needed information on how to effectively design those games. However, I quickly found that the majority of the material available was largely focused on mastering software necessary for creating game software [1] [2], rather than the design of games. The books that did touch on the design of games, only did so sparingly [3]. Design technique documentation on the internet regarding game design are extremely hard to find as well and, much like their book counterparts, more often than not focus on mastering software. Despite the fact that game design has been around for 30 years, we are still just throwing ideas to the wall and see what sticks. In doing so, we lose precious time and resources in what is essentially nothing more than re-inventing the wheel.

2.2Games are Becoming Increasingly Complicated

It is impossible to imagine current day society without interactive media anymore; games especially have penetrated every layer of society worldwide. The Entertainment Software Association has reported that 95% of the American population plays video games in some form or another [4]. Furthermore, the industry itself has reported staggering growth, with just the American market already being worth 22 billion dollar in 2013.

From its humble beginnings, games have grown rapidly both in terms of popularity as well as its technology. Modern games have become giant complicated productions combining fields such as advanced graphics technology, music, and complicated forms of interaction in order to create an immersive experience for the user.

Figure 2-1 Pitfall versus Uncharted 3: Drake's Deception

In [Figure 2-1] the game called "Pitfall!" (1982)[1] is compared to its modern counterpart, "Uncharted 3 Drake's Deception" (2011)[2]. Both are adventure type games, but there's a vast gap in how technologically advanced they are.

With the rapid evolution of games, it is easier than ever to overload the player with information and harder than ever to design an effective game. Furthermore, with the increasing demands of the market place, games have become very expensive to make and competition is the highest it has ever been. Companies more and more see themselves without wiggling room to make mistakes and will choose to play it safe rather than make new design decisions.

[1] Pitfall!, 1982, Activision Publishing, Inc.

[2] Uncharted 3: Drake's Deception, 2011, Naughty Dog, Inc.

3. RESEARCH GOAL

In order to create more effective games, and to further our understanding as to how interactive systems can be enjoyable to users, we posit that a fundamental understanding of design in interactive systems (notably those with entertainment as their primary purpose) is critical, especially for game designers. Therefore, we have focused our research on usability and user experience design to create new techniques that can be used by game designers for their games. We have tackled those fields from 2 angles that require a deeper understanding so as to not confuse the player; the objects with which the player can interact and the world these objects populate. In these 2 angles, we specifically researched challenge design, narrative and visual perception.

In chapter 4, we explore challenge as a core part of game design and aim to dispel certain misconceptions that exist within this design field. We will define basic forms of challenge that can help the designer make interesting games. We will also explore ways of how to design the defined challenges effectively. Last, we will explore challenges created by the player, as a means of enriching the game experience. In chapter 5, we explore design paradigms for using the physical world of the game world as a means of transferring narrative to users. For this, we have analyzed existing trends within game design and devised models in order to create more effective design. In chapter 6, we will delve deeper in the physical game world and explore the options of using visual perception in order to guide players through digital interactive environments. For this, we have concentrated on 2 areas. For the initial experiment, we analyzed the effects of color contrasts on participants, whereas for the second experiment we also used the luminance values of the stimuli for our analysis.

By researching these 3 areas, we will be able to create design methods for what makes up the majority of many games; the game world itself.

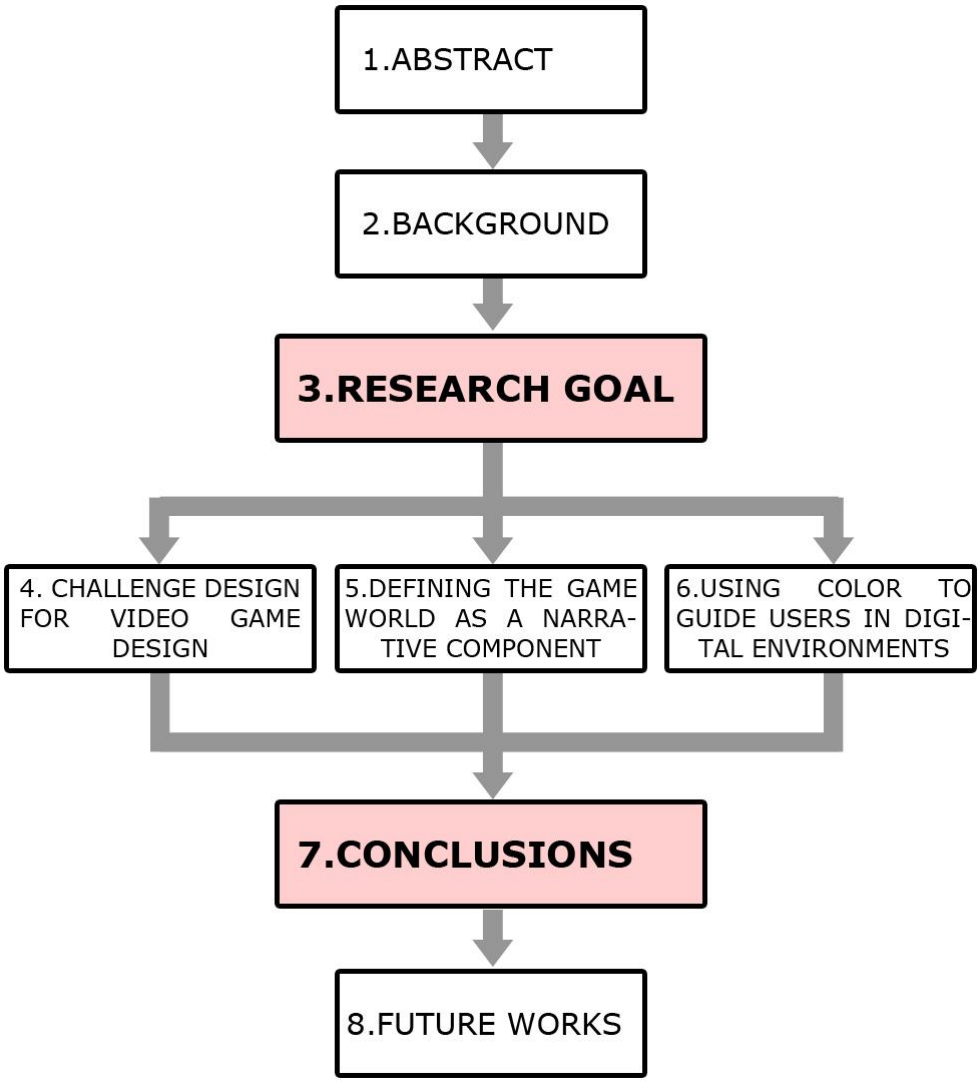


Figure 3-1 the correlations and dependencies between chapters in this paper.

4. CHALLENGE DESIGN FOR VIDEO GAME DESIGN

4.1Introduction

Even within the interaction design field, challenge is in many ways a unique concept. For design, the goal is generally to make experiences more accessible for users whereas challenge aims to achieve the opposite by making obstacles much more difficult to overcome. In the field of game design, challenge takes a very important role as most of a game revolves around overcoming challenges of various kinds. To games, challenge is a very important element to create a good user experience.

According to Malone, the theory of intrinsically motivating instruction is organized in three categories, namely challenge, fantasy and curiosity [5]. Furthermore, Cox argues that the theory of Flow is important to the immersion of gamers, which includes challenge as one of its components [6]. It follows from this that challenge is of major importance to games and is therefore something that needs further research. This is further confirmed by Johannes Huizinga, who stated that games are largely about overcoming something [7], giving further weight to the notion that challenge is integral to games. Juul, J., also heavily hints at this in his definition of what is a game, as games need to be "challenging" [8].

Since the earliest games like the famous Pong from the 1970's, games have developed into a huge industry that is now catering to millions of people. Within this timeframe, the industry has gone through many transformations and innovations. Not just in the sense of scope, but also in how games are being designed. One element that has not changed is how challenge remains a core component to the majority of games. However, while the need for challenge has not diminished, the ways challenges are designed has. Back in the earliest renditions of games, designers simply didn't know what made a good challenge. The result was a large variety of games that were too difficult, impossible even, an issue that largely remedied itself as designers gained more experience. Along with the experience gained, designers have found a large variety of ways to incorporate challenge into their games.

However, along with this experience, the definition of what is challenge in games has become vague, with a tendency of defining challenge through its difficulty. This trend is especially prevalent among game developers and players of games, as they often refer to challenge in games in how difficult they are [9] [10] [11] [12]. The goal of this research is to redefine challenge, in such a way that it can be properly designed and used for further research. We will approach the challenge as an obstacle present within the game world, meant to impede the player's progress in an enjoyable way.

4.2The Challenge Dilemma

Even though the challenge has become something of interest, the field remains largely unexplored and has led to an erroneous interpretation of what challenge entails. Game designers and academics alike seem to agree that a good challenge is one that is not too difficult nor to easy. Game designers often use the term "easy to learn, hard to master", as an ideal to strive for [13] [14]. This gives the impression a player should be eased into the game, giving the player enough instructions and practice for the player to master the basics. Through this definition, game challenge can be likened to the zone of proximal development [15]. In games, scaffolding often occurs through the game teaching the player what to do, in order to prevent frustration. Over the course of the game, the game presents more difficult challenges to overcome, taking into account the player's improvements in order to prevent the player from getting bored.

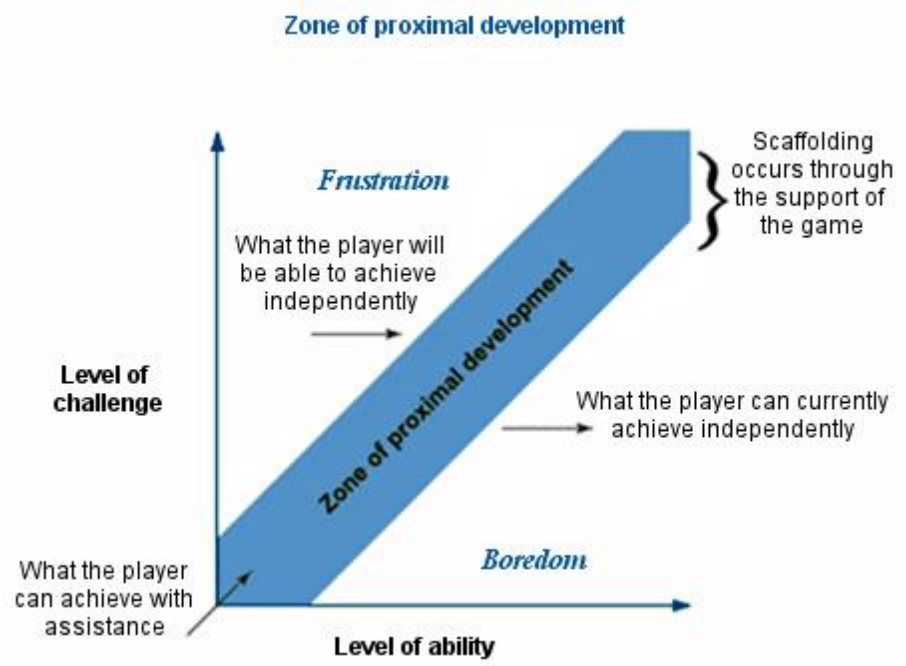


Figure 4-1 Zone of proximal development, modified for game design.

However, when looking at challenge, this is actually of little consequence. This is because no matter the difficulty level, there will always be players for whom the challenge is either well or ill-suited. Making a game too difficult from the start will alienate new players of games, but making a game too easy from the start will turn off experienced players as well. Some players learn fast, whereas some players learn slowly. When defining challenge through the means of difficulty, we are not defining the nature of the challenge, but we are defining the user group for whom the challenge is intended. In other words, if one talks about challenge in the context of difficulty, challenge becomes very subjective.

Furthermore, when defining challenge through its difficulty, we are actively ignoring the existence of various forms of challenge. If we look at this in reverse that also means that we are not able to effectively determine the difficulty of a challenge if we are not able to distinguish between what form of challenge we are looking at. A player of a role playing game, where most often a core component is to strengthen the

player's avatar through patient grinding[3], is experiencing a different form of challenge than someone who is playing a first person shooter, where the player needs to gain mastery of weapons in order to be competitive in the game.

Taking all of this into account, it makes a definition based on the difficulty of the challenge problematic. But why is defining challenge of such importance? In related research so far, it is hard to find a proper definition of what challenge truly is [16] [2] [17]. Crawford, C. has tried to define challenge, but defined it through its difficulty and concluded there is no objective answer to what challenge is [18]. However, by defining challenge, we will be able to better design one of the core components to a game. Furthermore, if we are to create a standard for genres within games, knowing what challenges there are within games becomes important, as a game cannot only be classified by its theme and setting, much like you would with a book or a movie. It is also a necessity for other challenge studies to have a base set of definitions in regards to challenge. For instance, it is necessary in studies such as those for dynamic difficulty [19], to know what forms of challenge exist in order to create dynamic renditions from those.

[3] Grinding is an activity where the player collects experience points through defeating enemies within the game world, in order to make the player's avatar grow stronger and become more competitive.

4.3Outline of the Challenge Research

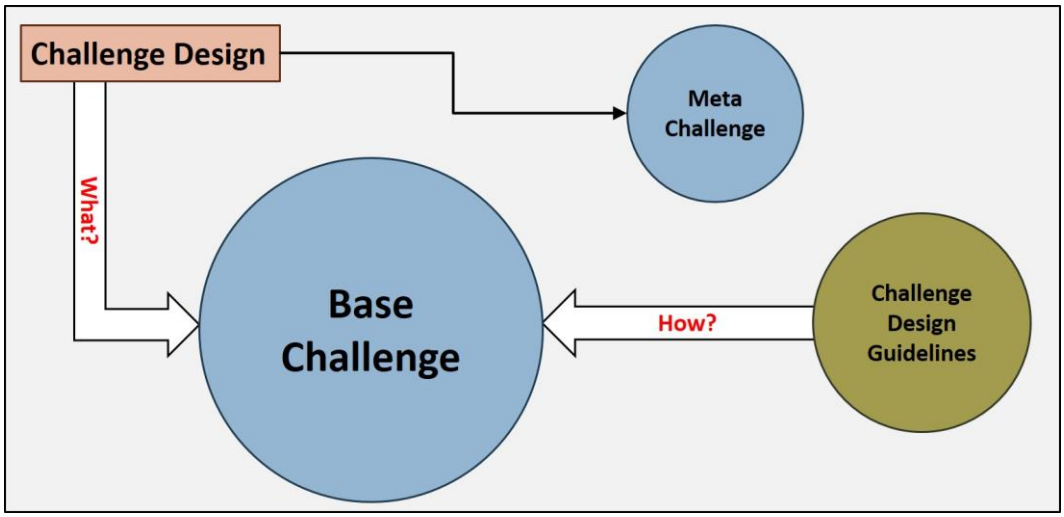


Figure 4-2 Outline of the challenge research

We first looked at what challenge was, which will be further explained in chapter 4.4. After that, we devised guidelines on how to design these challenges effectively, which we will explain in chapter 4.7. Finally, we looked at how players created their own challenges in order to make games more enjoyable for themselves, which we will explain in chapter 4.10.

4.4Categorizing Challenge

When looking to define challenge, we should not be looking at the height of the challenge, but rather what the challenge entails. For this research, we will be looking at challenge in its most basic form; challenge as an obstacle in the game world for the player to overcome. In order to properly define what makes a good challenge rather than a bad design, we propose a new paradigm to define it; we are going to be looking at how the challenge is designed and what major design trends can be observed when analyzing both old and new games. We decided to build upon the paratelic system proposed by Stenros [20], who used frame analysis to analyze the playing habits. However, instead of looking at the user, we used the definitions to look at how challenge was designed.

We conducted this research in two parts. With the first part we conducted an extensive software survey in order to analyze which kinds of challenge patterns could often be found in game design. During the software survey, we observed that players would not necessarily commit themselves to only pre-designed challenges and would often make their own as well. With the first part, we expanded on this by analyzing how often users participated in this particular kind of behavior to establish whether or not these forms of challenge were significant enough to define as their own kind of challenge.

4.5Method

4.5.1 Primary Research

4.5.1.1 Equipment

For most games that were surveyed, we used their respective consoles to analyze them. The consoles used were Nintendo, Super Nintendo, Nintendo 64, GameCube, Wii, Gameboy, Gameboy Advance, Nintendo DS, PlayStation, PlayStation 2, PlayStation 3, Xbox 360 and PC. For other games for which we either lacked the hardware or the ability to play, we used internet resources in the form of Let's Play's, which are video walkthroughs of games.

4.5.1.2 Protocol Design

For the software survey, we have attempted to test a wide variety of games across a wide variety of platforms, in order to ensure we would get the most complete picture of design trends within games when it comes to challenge.

#	Name	Numerical	Luck	Skill	Time	Pattern
1	Adventure of Link	X	X	X		
2	Alex Kidd in the Enchanted Castle	X	X	X		X
3	Alundra	X		X		X
4	Alundra 2	X		X		X
5	Angry Birds	X				X
6	Another Code					X
7	Banjo Kazooie	X		X	X	
8	Baten Kaitos	X	X			X
9	Batman Arkham Asylum	X		X	X	X
10	Battle of Olympus	X	X	X		
⋮	*See [APPENDIX C] for the full list of surveyed games.*					
198	Zookeeper	X			X	X
	Total observed	**187**	**70**	**140**	**62**	**158**

Table 4-1 A selection of the games used for the software survey

4.5.1.3 Data Analysis

Games were analyzed based on the core gameplay of the game as well as the obstacles within the game that were meant to challenge the player. Gameplay present within the game that was not part of the core gameplay was ignored. Stenros also looked at "griefing" [21] as a major component to player habits. However by design griefing is often discouraged and even fought by game developers [22] [23] [24], so we will not include this into our analysis.

4.6Results

In categorizing challenge types, we have identified the basic classifications base-challenge and meta-challenge. Base-challenge's defining feature is that it is designed. If the player plays the game like it is intended, the player will generally encounter and need to overcome a number of base challenges that are necessary to complete the game. Stenros referred to this as "playing the game." Within base challenge, we defined five subcategories, which are numerical challenge, luck challenge, skill challenge, time challenge and pattern challenge.

4.6.1 Numerical Challenge

The challenge of numbers relies on numerical values in order to challenge the player. The numerical challenges can be considered one of the oldest forms of challenges in digital video game design, e.g. in the early days players were often motivated to gain a so called score, an indicator of how well the player played the game.

There are two ways in which a numerical challenge can manifest itself; either through attrition or through strengthening. When a numerical challenge relies on attrition, it means that players of games need to be careful to not run out of a particular resource, whose amount is generally visualized through a number. Often these lead to abstract concepts, such as the concept of "lives" where if the player runs out of lives the player needs to start over again. Numerical attrition also works as a goal for the player; when the player has to reduce certain resources from opponents to zero in order to win the game.

Numerical strengthening on the other hand relies on getting as much of a certain resource as possible. The resource can generally not hit zero (and if it can, it does not result in the player having to start over again) and can bestow certain advantages on the player if the resource hits a certain value. A common example is experience. The player will gain experience through performing certain actions and if the experience value reaches a predetermined value, the player's avatar will gain advantages such as growing stronger or getting access to better equipment. Another form of numerical strengthening is through gaining points for a final score. In this case, the score does not bestow additional advantages when it reaches a certain value, but instead serves as the motivation to the player to perform better next time and improve on the score (a concept better known as high-scores, where players attempt to beat the previously set record). The concept of score was especially prevalent in early games, when games were generally limited to simple gameplay and had to rely on high-scores in order to increase the longevity of games. Score is often combined with time challenge.

Figure 4-3 Dark Souls[4]

In the game "Dark Souls," the player needs to strengthen his character through the use of souls. These souls are given to the player in a numerical quantity and, in order to strengthen his character, the player needs to pay these souls to in-game characters in order to improve the statistics of his character. A wide variety of statistics are available and they all affect various parts of the game. For instance, the statistic "Equip load" influences the weight of the armor and weapons the player can equip himself with. Going over the Equip load will cause the player character to become slower. The statistic "Stamina" influences how many times the player can strike with a weapon or defend with shield before the player needs to take a break to catch his breath. If the player's stamina runs out, the player character will be left undefended against the enemies and hazards in the game world. Furthermore, to use certain weapons, armor, and magic often requires the player to have a minimum of certain statistics. This game relies on strengthening a wide variety of statistics in order to remain competitive to enemies and other players.

[4] Dark Souls, 2011, From Software Co., ltd

4.6.2 Luck Challenge

The challenge of luck is one where the computer decides randomly on certain events, such as chance. It is generally determined by a random number generator that has been built into the game.

An example of a luck challenge occurs in games where players can get items from defeated enemies through chance. The computer randomly decides whether the player will get an item and what item the player will get.

Figure 4-4 Final Fantasy X-2

In the Final Fantasy X-2[5], the player can play an optional game called "Sphere Break." The goal of this game is to create multiples of the number in the blue sphere, using at least one bronze coin and as many silver as the player sees fit. The game consists of a number of turns, in which the player needs to meet a quota of used silver coins. At the start of every turn, the number of the blue sphere changes to a random number. The numbers on the bronze coins are randomly decided at the start of the match, and remain the same throughout the game as the bronze coins will not disappear once used. The numbers on the silver coins are also randomized at the moment they appear. Once used, silver coins will

[5] Final Fantasy X-2, 2003, Square Enix Co., ltd.

disappear. Furthermore, during the match the game will often remove unused silver coins and/or place new silver coins for the player to use. The rate at which these appear and disappear is also randomized.

4.6.3 Skill Challenge

A challenge of skill is when players are required to master certain moves that are required to overcome obstacles in the game. These can come in the form of the control scheme, where the player is constantly subjected to challenges growing more and more difficult using the same control scheme over the game. This form of challenge is common to platforming[6] games. Another form of this challenge is the one where players gain various items with different uses that the player needs to master. This particular form of challenge is especially prevalent in action adventure games, where the player gains different tools that are needed to solve different puzzles.

Figure 4-5 the Legend of Zelda Skyward Sword.

In The Legend of Zelda Skyward Sword[7], the player controls a character that wields a sword. In order to overcome the challenges within the game,

[6] A platforming game is a game where the player needs to run and jump through an obstacle course.

[7] The Legend of Zelda Skyward Sword, 2011, Nintendo Co., ltd.

the character needs to master the use of this sword not only to remain competitive when battling enemies, but also to solve puzzles using specific sword motions. Furthermore, the player gains access to a wide variety of items, whose control methods often differ from that of the sword. Like the sword, the player needs to master these items too, as certain elements in the game world (such as puzzles and items) can only be overcome by correctly using the item in question.

4.6.4 Time Challenge

During a challenge of time, the player is forced to complete a certain task within a set amount of time. Failure to do so will either result in the player having to do the game over or the player having to redo the task once more.

In earlier games, it was common for the game to largely be about doing certain tasks within a time limit. For instance, in platforming games the player would have to get to the goal of the level before the time was depleted or else the player would have to start over again. Another early application was in score based games, where players had to get an as high as possible score in a set amount of time.

Modern applications generally limit the time limits to singular tasks, with only very few elements within the game relying on a time limit.

Figure 4-6 Gran Turismo 5

In Gran Turismo 5[8] the player can play a particular game mode known as "Time Trial.[9]" In this game mode, the goal for the player is to try and set a time record on the particular track the player is racing on. Often games contain visual feedback of the player's best record often in the shape of the car the player used to set the record (which is then made semi-transparent to make sure the player can clearly see which car the player is currently using). Due to its semi-transparent nature, this is often known as a "ghost."

4.6.5 Pattern Challenge

Pattern based challenges rely on the memory of the player. The player needs to memorize patterns within the game world, its enemies and all the other involved objects in order to overcome the challenges laid down by the game. Especially encounters with hostile entities are often designed to exhibit specific behavior patterns depending on how they are approached by the player. The player will then need to learn those patterns and use them to his advantage. Another use of pattern based challenge, which was often used in older games, is where the world itself becomes part of the pattern based challenge.

Challenges of this kind often required the player to memorize the placement of enemies and hazards within the world; because if the player was unable to, the repercussions would generally be harsh (i.e. the player would often have to retry the stage being played from the start or even start over the entire game). This is also known as "trial and error" game-play, as players often needed to keep trying until they remembered every obstacle to a tee.

[8] Gran Turismo 5, 2010, Sony Computer Entertainment, Inc.

[9] Time trial is a game mode that is common to racing games and can be found in the majority of racing games.

Figure 4-7 Advance Wars Dual Strike.

In Advance Wars Dual Strike[10] the player needs to wage war with the opponent and needs to use vehicles and soldiers to overcome the opponent. Each unit has its own strengths and weaknesses and it is up to the player to use the units to their full advantage. In [Figure 4-7] an example of a battle between the player and enemy is shown. The player's units are red whereas the enemy's units are blue. In this example, the player has a lot of units that are effective against aerial units, which the player needs to use to disable the airplanes.

4.7 Creating Design Heuristics to Create Effective Challenges

After defining the base challenges, we analyzed how these base challenges could be designed in such a way that they would not frustrate players of games. For this, we created challenge design heuristics, or guidelines, by which proper challenge design should abide. We developed a total of six

[10] Advance Wars Dual Strike, 2005, Nintendo Co., ltd.

design heuristics after analyzing the games we observed for our base challenge definitions.

4.8 Method

4.8.1.1 Equipment

For most games that were surveyed, we used their respective consoles to analyze them. The consoles used were Nintendo, Super Nintendo, Nintendo 64, GameCube, Wii, Gameboy, Gameboy Advance, Nintendo DS, PlayStation, PlayStation 2, PlayStation 3, Xbox 360 and PC.

4.8.1.2 Protocol Design

For the software survey, we used the games we surveyed during our research into base challenge categories as described previously.

4.8.1.3 Data Analysis

Games were analyzed based on the core gameplay[11] of the game as well as the obstacles within the game that were meant to challenge the player. Gameplay present within the game that was not part of the core gameplay (in other words, challenges that were not required to complete the game) was ignored.

4.9 Results

4.9.1 Core Gameplay

A challenge should be solvable through the core game-play as established by the game.

A game should clearly establish what core game-play the game offers and should not deviate from that established core. All challenges the player must solve need to be solved through this core game-play. It should be noted that this does not refer to additions which complement the core

[11] The core gameplay is the main means of interaction the player has with the game environment.

game-play, but rather elements that completely differ from the core game-play.

An often recurring problem in Japanese Role Playing Games is that the game requires the player to complete a mini-game[12]. This becomes an issue when successfully completing that mini-game is a necessity in order to complete the game or gain important resources for progression that cannot be gained otherwise.

Figure 4-8 Xenogears. The left part of the image shows the core game-play, whereas the right part shows a mini-game that needs to be completed to advance the game.

The core game-play of the game Xenogears[13] involves the player and enemies taking turns. When the turn arrives, the player can choose what actions the player's avatar has to take. However, when the player arrives at the midpoint of the game, the player will have to play a mini-game called "battling," which is essential in advancing the game. This mini-game is the opposite of what is established during the core game-play, in that it does not have the turn mechanic and is thus much more action oriented.

It should be noted that this heuristic only applies to challenges that are necessary to complete the game. For challenges that are optional to complete the game, it does not necessarily pose a problem if the core

[12] A mini-game is a small game within the main game itself, with rules that often differ from those established by the core game-play of the game.

[13] Xenogears, 1998, Square Co., ltd.

gameplay differs and may actually enrich the overall gameplay by offering variation.

4.9.2 Technical Implementation

Challenge should not be marred through bad technical implementation.

A challenge should not be dependent on a faulty control scheme or otherwise faulty elements that prevent the player from overcoming challenge encounters within a game, such as (game breaking) bugs. Overcoming challenges should only be made more difficult through the encountered challenge itself, e.g. by introducing additional obstacles to a challenge that was previously overcome by a player. We should note that these concern flaws that affect the actions the player can undertake.

A common example of this flaw is the player camera. Since a player camera influences how much the player can see at any given time, the role of a player camera is of utmost importance in a game. Especially in games where the game-play requires the player to make skillful maneuvers, it is important that the player has a good understanding of the area in which the player current resides in. However, what often happens in games is that the player camera cannot be controlled or the camera working against the player, thus making maneuvers needlessly complex and often even frustrating.

4.9.3 Player Actions

The outcome of a challenge should largely be determined through the actions of the player.

A player should have the ability to contribute a reasonable amount of input in order to overcome a challenge. When the outcome of a challenge is predominantly determined through outside influences, such as luck, it becomes a design flaw.

A common example of this particular challenge design flaw is in games where co-operation with a computer controlled character is necessary in order to beat the game, especially when the loss of said character results in a game over for the player. In these events, the AI of the character is of utmost importance in order to make the game playable. In the event that

it is not and the computer controlled character causes more work and frustration for the player, it becomes an example of this particular design flaw.

Figure 4-9 Resident Evil

In Resident Evil 5[14], the player controls one character, whereas the other character is either controlled by a friend or by the computer. To finish the game, the player cannot lose this partner. However, if the partner is controlled by the computer, it will rush into enemies, fail to help the player or spend necessary items without any foresight thus creating a challenge where the player has little to no influence on the outcome.

4.9.4 Information

The player should have at all times all the necessary information in order to complete a challenge.

A game should provide all the necessary information required to overcome the challenges in the game and should not require additional knowledge from outside of the game in order to complete it. This also refers to obscured content within the game that is essential for the player to see in order to effectively overcome it (such as an enemy sniper that can shoot the player from outside of the player camera's field of view).

[14] Resident Evil 5, 2009, Capcom Co., Ltd.

An example of this design flaw regards platforming games[15], games where the player needs to control an avatar and make his way through an obstacle course to reach the end of the level. Often, in these games, there are so called endless pits, holes that mean instant death if you fall into them. Because of this, these holes are associated with certain death and give the impression that they should be avoided at all times. Certain games however, require you to dive into one of those holes in order to find exits or secrets. Since this goes contrary to the player expectations and the game never gives the information that these endless pits could contain secrets, it should be considered a design flaw.

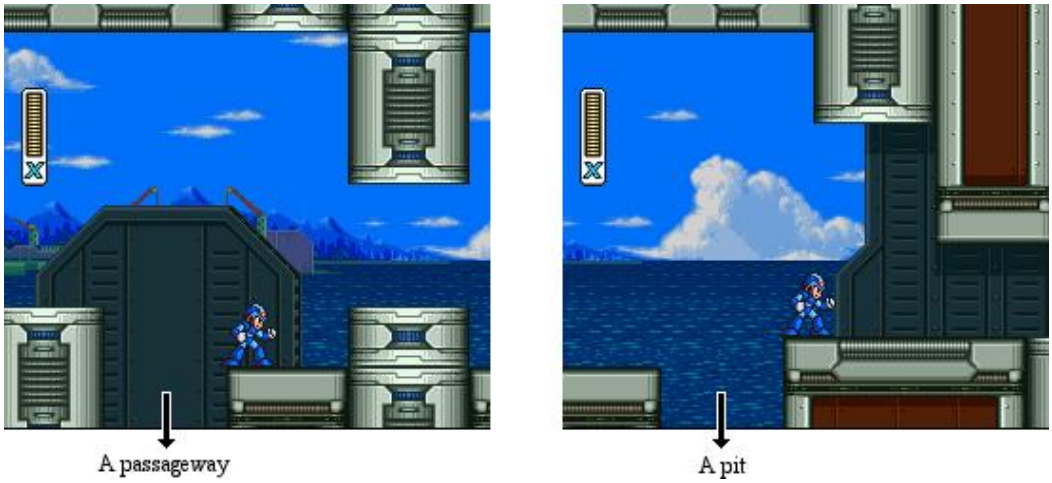


Figure 4-10 Mega Man X 3

In Mega Man X3[16], the player needs to avoid pits, as falling in a pit means the player has to start over. However, oftentimes there are passageways that look identical to pits, thus requiring the player to make a leap of faith.

4.9.5 Effects on Future Challenges

The player should be aware of the ramifications player's actions can have on future challenges.

[15] A platforming game is a particular type of game where a large part of the challenge comes from running and jumping over obstacles.

[16] Mega Man X 3, 1995, Capcom Co., ltd.

A player should always be aware what he can expect to happen in the future course of the game, when it regards elements that can impede the player's progress.

A very common example consists out of so called "miss-ables," which are items in a game that are only available for a limited amount of time. Oftentimes, the player is not informed about the limited available of the item, or even of the item itself. The player can often only find out by chance the player is missing an item, or needs to look up guides for help in order to find them. This is especially frustrating when the item needed for completion of the game was a miss-able item and the player becomes unable to complete the game.

Figure 4-11 Final Fantasy Adventure

In Final Fantasy Adventure[17], the player needs to open locked doors with keys bought in villages. After entering the final dungeon, the player will be unable to go back again. However, the player is unaware of how many keys the player will need in this dungeon. If the player does not have enough keys, the player will be unable to advance and will need to restart the entire game.

4.9.6 Challenge's Advantage

The challenge should not have an unfair advantage over the player.

In early days, artificial intelligence (AI) in games was often limited by technical limitations of the hardware. For that reason, designers would give the AI advantages over the player in order to make the game more

[17] Final Fantasy Adventure, 1991, Square Co., ltd.

competitive to the player and to compensate for lacking processing power. This gave rise to a myriad of ways in which the AI could be "cheating" the player.

Figure 4-12 Mario Kart: Double Dash!!

An example of this challenge design flaw is "rubber band AI," which is often used in the Mario Kart series of racing games[18]. What this particular kind of AI does is that when computer controlled opponents are lagging behind the player, they are given advantages in order to remain competitive and thus keep the challenge interesting. However, in various games this causes the AI to gain abilities that were otherwise impossible to have (e.g. having cars that become faster than their supposed maximum speed in racing games). This in turn causes frustration for the player as the player is unable to overcome the odds even though technically, the player should be able to do so.

[18] Mario Kart: Double Dash!!, 2003, Nintendo Co., ltd.

4.10 Meta Challenge

While we conducted the software survey to determine the base challenge categories, we also observed player behavior. When we observed players and did user surveys, we found that the participants did not limit themselves to base-challenges alone, and instead would create their own challenges as well. We called this phenomenon meta-challenge, which is challenge that is designed by the player. Meta-challenge can have a wide variety of goals; from making the game more difficult to even making a completely different game within the game itself. Meta-challenge is not obligatory in nature; the player does not need to overcome meta-challenges in order to finish the game. Due to this, it is not necessary for the designer to take into account meta challenge while designing games. However, if the designer chooses to take it into account, the designer can enrich the user experience. Stenros [20] referred to meta challenge as "playing the system." We identified four subcategories of meta challenge, namely lusory challenge, peripheral challenge, hoarding challenge and speedrun challenge.

4.11 Method

4.11.1.1 Participants

There were a total of 34 participants ranging from students to professionals, of which 70.6% was male and 29.4% was female. The average age was 24.5 years old, with a standard deviation of 4.7. Participants were from varying nationalities.

4.11.1.2 Preparation

A questionnaire was prepared to question participants on their player behavior in the game, with focus on non-designed challenges.

4.11.1.3 Protocol Design

Observations were conducted into online communities of players to find whether players would engage in activities that were generally not

required to complete a game. Among the observed communities were communities that specialized in walkthroughs[19], wikis that concentrated on particular games and communities that concentrated on specialized pastimes such as speedrunning, a particular kind of meta challenge that shall be explained later. Communities that were observed were;

- www.gamefaqs.com
- demonsouls.wikidot.com
- www.zeldaspeedruns.com
- www.lparchice.com
- www.youtube.com
- www.nuzlocke.com/challenge.php
- www.tasvideos.org
- www.speedrunslive.com

Furthermore, a questionnaire was developed based on the most common forms of behavior that we observed, to analyze to which extent players would engage in these non-obligatory activities. The questionnaire consisted out of five parts. The first part requested basic information from the participant, namely age and sex. The other four parts concentrated on each of the four types of meta-challenge we observed and the player habits in regards to those types.

4.11.1.4 Data Analysis

In observing communities, special attention was given to behavior that was not necessary to completing a game. For this, we examined guides on how to perform this behavior, recordings of this behavior in the form of video or online discussions between players to ask, promote or inform about particular forms of behavior.

[19] Walkthroughs are extensive documents that provide information on games, from elements like collectables to how to complete the game step by step, often written by amateurs.

4.12 Results

4.12.1 Lusory Challenge

In Rules of Play [16], Salen and Zimmerman outlined the lusory attitude, as defined by Suits, B. as

> *"In anything but a game the gratuitous introduction of unnecessary obstacles to the achievement of an end is regarded as a decidedly irrational thing to do, whereas in games it appears to be an absolutely essential thing to do."*

This refers to the way players perceive game rules and how they often forgive rules that makes a game more challenging, but whose effectiveness in the real world would be debatable.

However, the lusory attitude can not only be applied to the reason why people don't mind game rules, but also to how certain players approach challenges already set by the game. The latter is what we refer to as lusory challenge. It is the act of the player creating optional challenges for himself that are far more difficult to overcome than the initial challenges set by the designers, while still completing the final game goal that the designers had set.

We found that 82.4% of the participants participated in lusory challenges.

Figure 4-13 Final Fantasy

In Final Fantasy[20], the player controls a group of 4 characters. These characters can have a variety of roles which makes them adapt at specific tasks, such as casting magic, attacking with a sword or stealing items. To complete the game, the player is required to make a balanced group so that the player can remain competitive against enemies.

In order to make the game more difficult for themselves, people have completed this game setting themselves a wide variety of limitations. In [Figure 4-13], one player has challenged himself to complete the game with nothing but White Mages, whose role it is to heal other characters and are the weakest job in terms of raw physical strength.

4.12.2 Peripheral Challenge

In Peripheral Play [25], Geurts investigated the phenomenon of free play within a game and named the phenomenon peripheral play, as the peripheral play exists within the game world, but (mostly) outside of the rules of the game. She defined it as free play within the boundaries of the game world.

[20] Final Fantasy, 1987, Square Co., ltd.

We define peripheral challenge as challenges that are born from peripheral play. Due to the free nature of peripheral play, peripheral challenge can take, but is not limited to, the form of base challenges. We should note that while all set challenges born from peripheral play are considered to be peripheral challenges, it is not necessarily the case that all forms of peripheral play result in the birth of peripheral challenges.
We found that 70.6% of the participants participated in peripheral challenges.

4.12.3 Hoarding Challenge

Hoarding challenge is the player's need to get every item that is possible to get in a game. Often these days, games contain a lot of challenges to cater to that need, often nicknamed "collect-a-tons"[21]. These are most often kept optional. Hoarding challenge refers to any behavior where a player needs to get his hand on something that is not required for the completion of the game.
While it could be argued that a hoarding challenge should be considered a base challenge, we should consider that even if no "collect-a-tons" are present within the game, players will still attempt to collect elements that were not meant to be acquired in full. An example of this would be Final Fantasy Four Heroes of Light. While the game does not require the player to collect every item, and actually discourages it by limiting the amount of items a player can hold at any given time, players have still created methods of getting all the items in the game, complete with information on where to get the item, when to get the item, how to get the item and how big the chance is of the player getting the item. [26]
We found that 88.2% of the participants participated in hoarding challenges, making this the most common meta-challenge for players to

[21] Games often contain elements where the player is motivated to collect certain kinds of items of which there is a select amount hidden within the game world. These items will often yield extra rewards for the player once a number has been collected and are voluntary in nature. These are known as "collect-a-tons."

participate in. Furthermore, we found that 58.8% of the participants also expressed a desire to get all collectibles available in a game.

Figure 4-14 Final Fantasy 7.

In Final Fantasy 7[22], the player can acquire a wide variety of items with various purposes. Furthermore, for every single item, the player can carry a maximum amount of 99 items. However, getting every item in the game is exceedingly different and often discouraged by design. Despite this, as [Figure 4-14] shows, players have attempted at not just collecting every item in the game, but also to gain the maximum number of any particular item.

4.12.4 Speedrun Challenge

Speedrun challenge has certain parallels with lusory challenge in that it is about the player setting himself a goal to beat the game in a different way. However, as opposed to lusory challenge, where the primary goal is to make challenges more difficult to overcome, with speedrun challenge a player competes to complete the game in the fastest time. Among gamers, this particular feat is also known as speed-runs, which is where the name for this challenge came from.

[22] Final Fantasy 7, 1997, Square Co., ltd.

While taking on a speedrun challenge, players often share their findings online, creating a competitive environment where players compete for the fastest possible time. There are two forms of speedrun challenge, namely tool-assisted and regular.

Tool assisted means that the user made use of a video game console emulator[23] that can slow down the frame-rate of a game for higher precision (and thus a better time when played back on normal speeds). Players will often abuse glitches and hacks within games in order to get to the end as fast as possible. Players will use any means necessary to get the fastest time.

A regular speed-run is the opposite of that, where players compete for the fastest time playing the game like they normally would, using only whatever features are available on the original hardware. Video game console emulators are sometimes used, but only for the purpose of playing the game rather than using the functionality available within the emulator software. Sometimes, players do a regular speed-run in segments, where they replay (groups of) video game levels where they can retry as much as they want and only the fastest time counts. This is also known as a segmented speed-run.

With the advent of the internet, doing speed-runs has become easier with the existence of websites such as YouTube where players can upload their speed-run results in order to compete with other players of games. Furthermore, there exist a slew of communities whose primary goal is to educate players on speed-run strategies or what kind of speed-runs can be done on any particular game, as well as to record the fastest speed-runs on the games that they give information about.

We found that 50% of the participants participated in speedrun challenge, making this meta-challenge the least popular meta-challenge.

[23] Video game console emulators are software that aims to emulate a console, so that the games for said console can be played on hardware other than the original video game console.

Figure 4-15 Zelda Ocarina of Time live speedrun broadcast.

[Figure 4-15] shows an example of a speedrun. Originally, the game The Legend of Zelda Ocarina of Time takes around 20 to 30 hours to complete, if a player is inexperienced and completes the game the way the designers intended. However, with the speedrun being broadcasted in the above figure, the player aims to achieve to complete the game within 25 minutes. This is done through using bugs that are present within the game software so that the player can skip large portions of content that would otherwise increase game-play time.

4.13 Limitations

A limitation of this study is that it has focused on games that already have been created; it doesn't take into mind new kinds of challenges that may be created in the future. Therefore, the categorization and sub-categorizations are not exhaustive. Another limitation is that this study does not take into account female playing behavior. It can be argued that the majority of video games have been created with a male audience in mind, with males being the dominant workforce in game development even to this day [27]. When we surveyed player habits in relation to meta-challenge, 71% of the participants were male. Therefore, the forms of challenge and playing habits observed in this paper do not necessarily

reflect how a female target audience would approach challenge in games. However, even with those limitations, we feel that this study is necessary to understand games and challenge in games.

5. DEFINING THE GAME WORLD AS A NARRATIVE COMPONENT

5.1 Introduction

In the previous chapter, we explored challenge as an important tool for game designers in order to make games interesting for the player. However, just improving the usability of challenge is not enough to make sure that games will not become frustrating to players. We also need to take a look at the containers in which the challenge takes place, namely the game world itself. Since games have grown technically complicated, both in terms of interaction as well as graphics technology, players can get easily overwhelmed by the graphical content within the game as well. Since the graphical content of the game world often has narrative properties, we decided to first look at those narrative properties, to enable designers to create better game worlds.

However, most often when talking about the presence of narrative within games, game designers and academics alike often refer to classic narrative elements. Even if they refer to in-game objects that have a narrative function, they refer to objects that can fill the role of a narrator.

In Formal Abstract Design Tools [17], Church argues that the game story does not necessarily mean "expository prewritten text," but rather that it refers to

> *"Any narrative thread, whether design-driven or player-driven, that binds the events together and drives the player forward to the completion of the game." (As cited in [28])*

With this definition in mind, we can argue that the game world is able to be a narrative component as well. In fact, since the game world is the container to all elements that are needed for the player to complete the game in the first place, we might even consider the game world to be one of the most important narrative components within the game.

More than any other medium, users of games are continuously exposed to the game world. Not only in terms of average game length, but because games are interactive by nature. Users can find themselves revisiting

previous locales because the narrative demands it, the user feels there is still unfinished matters present within the locale, because users need to return due to a precious resource only available in particular locales, and so on. In fact, it could be argued that through most of the game, the user is actually not involved in advancing the plot of the game, but instead hard at work simply playing the game by immersing himself and interacting with the game's environment. This requires the user to take up the game world in greater detail, as it is a necessity in order to complete the game. More so than the worlds contained within traditional media such as movies or books, players find themselves involved with the world itself.

One could argue that these player actions are a part of emergent narrative, where the user's actions determine the shape of the narrative. However, before actions that build emergent narrative can take place, the locations in which these actions take place need to be established first to give players a reason to interact with them. The goal of this paper is to look at the game world as a narrative component and to form definitions and models through an extensive software survey. The validity of these definitions and models will be tested through their ability to immerse the player into the game world.

5.2Using the Visual Aspects of Games for Usability

One could argue that usability is not an inherent necessity for games. It is true that games, unlike other interactive products, seek to challenge their players in order to create satisfaction, like we explored in chapter 4. However, as we already found, just because something is difficult, it doesn't necessarily mean it is enjoyable.

Furthermore, Koster, R., argued in A Theory of Fun [29] that having fun is all about the brain releasing endorphins into our system, and that the way to do that is to learn something new or master a task. Games in this sense are ideal for the task, since they are largely about mastery and comprehension. He referred to the rules within games as patterns and argued that once the player fails to see any patterns whatsoever, he will experience noise and become frustrated with the game.

Game creators have already developed a few methods of ordering this noise into information that is easier to understand. For instance, Isbister, K., noted in Better Game Characters by Design [30] that the character Link from the game The Legend of Zelda The Wind Waker[24] has large eyes that makes tracking his gaze easier.

Figure 5-1 the Legend of Zelda the Wind Waker

During the game, the character will often look at objects that may be of interest to the player. As can be seen in [Figure 5-1], Link's gaze will automatically look at enemies so that the player can be aware of where enemies are located. There are other games that employ this particular technique of the main character looking at objects of interest, such as in the game known as Fatal Frame, a horror themed game developed for the PlayStation 2.

In order to make sure games do not become frustrating to players, to both experienced and inexperienced players alike, it is not just necessary to explore the ways players play the game through how games challenge players, but also through how players interact with the game world.

[24] The Legend of Zelda: The Wind Waker, 2002, Nintendo Co., ltd.

5.3Preliminary Research Method

5.3.1 Equipment

For most games that were surveyed, we used their respective consoles to analyze them. The consoles used were Nintendo, Super Nintendo, Nintendo 64, GameCube, Wii, Gameboy, Gameboy Advance, Nintendo DS, PlayStation, PlayStation 2, PlayStation 3, Xbox 360 and PC. For other games for which we either lacked the hardware or the ability to play, we used internet resources in the form of Let's Play's, which are video walkthroughs of games.

5.3.2 Protocol Design

For the software survey, we choose games in which the player had to control an avatar in order to interact with a digital game environment. Therefore, games that were more abstract in nature, such as puzzle games and rhythm games, were largely ignored.

Platform	Title
Nintendo	Chrono Trigger, Super Mario World, Tetris, The Legend of Zelda A Link to the Past, Terranigma, Lost Vikings, Little King's Story, Muramasa the Demon Blade, Illusion of Gaia, Golden Sun, Castlevania Portrait of Ruin, Banjo Kazooie.
PlayStation	Wild Arms, God of War, Jak & Daxter, Ratchet & Clank, Prince of Persia, Uncharted, Folklore, Okami, Digital Devil Saga, Viewtiful Joe, Final Fantasy X.
Personal Computer	Dishonored, Super Meat Boy, Mark of the Ninja, Super Monkey Island, Day of the Tentacle, Psychonauts, Bioshock, Overlord, Deus Ex Human Revolution, Darksiders 2.
Xbox	Kameo Elements of Power, Blue Dragon, Final

	Fantasy XIII.
Sega	Sonic The Hedgehog, Skies of Arcadia.

Table 5-1 A selection of the games used for the software survey

5.3.3 Data Analysis

Games were analyzed on how the progression in the game was structured. Furthermore, the narrative spaces and narrative descriptors within the games were analyzed to find recurring themes among them. Lastly, we analyzed whether games had narrative that was not necessarily relayed to players in the game itself, but whose presence was either hinted at in the game or whose presence was further explained through other media, such as books.

5.4Preliminary Results

5.4.1 The Game World as a Narrative Component

When looking at the game world as a narrative component, Salen and Zimmerman defined two properties in the book Rules of Play [16] that could define the world as a narrative component, namely narrative spaces and narrative descriptors.

- Narrative space is the 2D or 3D space in which a game takes place.
- Narrative descriptors are the representations within the narrative space that help players understand the activity in the game within a larger narrative context.

Unfortunately, the issue with Salen and Zimmerman's definition of those elements is that it is too simplistic. The example they used to explain their definitions, namely the game Asteroids, is a game that consists out of only one screen with very few elements. While their definitions may hold true for a game of this scope, when looking at games of a broader scope, their definitions fall flat. Therefore, building on these definitions as a base, we sought to expand these definitions.

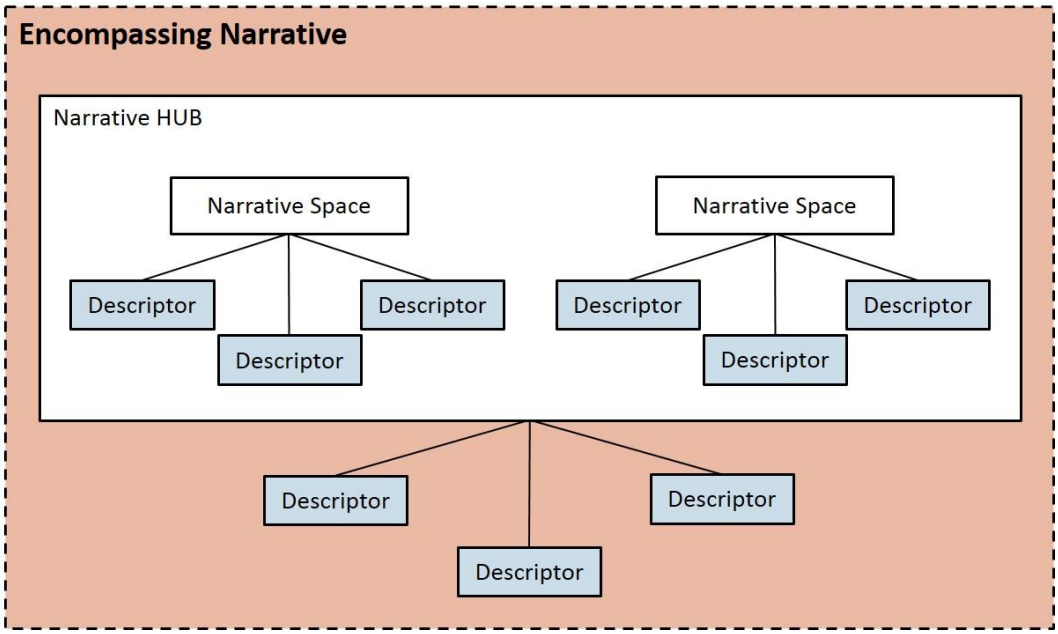


Figure 5-2 the game world as a narrative component research outline

[Figure 5-2] shows an overview of the expanded definitions that we created during the course of our research. These expanded definitions will be explained in the coming chapters.

5.4.2 Encompassing Narrative

One thing that Salen and Zimmerman's elements do not take into account is the massive amount of background information that is present in today's games. Case in point is the game World of Warcraft, as well as antecedent games in the franchise. These games have a vast lore regarding its universe, including novels to explain history that took place before the timeline in the games. This lore is not necessarily disclosed to the player in the game itself, but it serves as important guidelines to shape the world of the game.

The encompassing narrative consists out of all the base information that is needed to build all the locales within the game; it gives form and identity to the narrative spaces and descriptors present in the game world. This includes, but is not limited to, the game world's history, the races that inhabit the world and the sociological properties of the game world.

The encompassing narrative is generally not communicated directly to the player, at least not in its entirety.

Figure 5-3 Genso Suikoden 2, while a character receives the Black Sword rune.

According to the lore of the game series Genso Suikoden [31] the fictional world of Genso Suikoden is based around the existence of true runes, which are considered as gods in this world. Many conflicts and stories within this universe revolve around these true runes and the games often show that these runes have the power to make or break the world. For instance, in the game Genso Suikoden 2[25], the player encounters the Rune of Beginning, which in the lore of this world represents the "initial chaos of birth" inherent in times of creation. This rune is split into two, namely the Black Sword [Figure 5-3] and the Bright Shield rune, and becomes the primary reason for the protagonist and antagonist to fight one another.
The origin of the true runes, as well as their identity is never fully explained to the player. Throughout the games series they are slowly introduced, but other than that they exist as base information to give the world of Genso Suikoden its shape and form. Furthermore, mentions of past cultures and civilizations are made during the game, but information

[25] Genso Suikoden 2, 1998, Konami Digital Entertainment, Inc.

regarding these cultures and civilizations is never fully disclosed to the player. They often serve to give identity to areas the player has to explore.

5.4.3 Narrative Spaces

Narrative spaces are the containers that hold all of the descriptors. They can be considered the game's locales. They serve as the basic forms that the descriptors will take and are therefore more abstract in nature. Whereas the encompassing narrative contains information that is not necessarily present within the game itself, the narrative content of the narrative spaces are all available to players.

5.4.3.1 Narrative HUB

The narrative HUB differs from a normal narrative space in that it has a central role. While narrative can be present within a narrative HUB, it is limited compared to a normal narrative space. It is made to connect a wide variety of narrative spaces together so that players can easily (re)visit those spaces.

A common incarnation of the narrative HUB used in the Japanese role playing games is the so called world map. In the world map, the player wanders across a miniature version of the entire accessible universe of the game. On the world map exists icons of locales, such as towns or caves. These icons serve as the entrances to new narrative spaces.

Figure 5-4 Mario 64

In Mario 64[26], the player will find himself in a narrative HUB that takes the form of a giant castle [Figure 5-4]. Within the castle are paintings, which the player can enter. If the player enters one of the paintings, the player will be transported to a new narrative space, with the theme of the narrative space resembling the theme of the painting. Once the player completes an objective within the narrative space, dies or decides to quit, the player is returned back to the giant castle. Once the player has access to the narrative space, the player can enter them at any given time as he sees fit.

5.4.4 Narrative Descriptors

Descriptors are the smallest quantifiable part of the visual design of a game world; they are the building blocks that give meaning to the narrative space and communicate their role and the role of the narrative space to the player. There are four kinds of descriptors that can be present within a narrative space.

5.4.4.1 Narrative Descriptor

Narrative descriptors are descriptors that primarily fill a narrative function and they serve as the most basic of descriptors. They serve no to limited interactivity to the player and serve to establish the role of the narrative space they are located in. Through their presentation, they can also provide the player with information regarding the history of the locale and the relation of the locale to that of others.

[26] Mario 64, 1996, Nintendo Co., ltd.

Figure 5-5 the Book of Unwritten Tales.

In the game The Book of Unwritten Tales[27], the player will eventually find himself near the city of Seastone, a fictional city that resembles a (small) kingdom [Figure 5-5]. Looking at how the kingdom is designed we can conclude the following before we even enter the kingdom. The wall for defense indicates that at one point, the city was prosperous enough to warrant protection from outside influences. The high houses further confirm this. However, we can also conclude that while it was prosperous at one point in time, the city is currently past its prime since the city walls are starting to fall to ruin and repairs are either non-existent or not very well done. The vine growth further confirms this. The small road indicates that while the city was prosperous, it never attracted a large commerce, since the roads would have had to be bigger if that were the case. The relatively small city gate further confirms this, though it could also be the case that this is not the city's main gate and therefore not the usual place from which merchants would enter. The festival ornaments indicate that the current is currently having some festivities.

[27] The Book of Unwritten Tales, 2009, King Art.

5.4.4.2 Functional Descriptor

Functional descriptors do not necessarily communicate the narrative role of the narrative space to the player. They serve to give the player a point of reference from a game-play perspective.

Figure 5-6 In Alundra, the player can use a "magic bean" on flower pot objects.

In Alundra[28], by progressing through the game the player receives a set of special items. These items will help the player reach locations the player couldn't reach before. One of these items is called the "magic bean" [Figure 5-6]. The player can only plant the magic bean in flower pots that specifically exist for this purpose. Once planted, the pot will generate a spring loaded plant, which will propel the player character to higher places that could not be accessed normally. No matter where the player is, the shape and size of the pots doesn't change. This will cause the player to instantly recognize a place where a magic bean can be planted.

However, from a narrative standpoint, the flower pots make no sense. They are scattered everywhere throughout the game world, even in places were the existence of a flower pot would be strange, such as in the middle of a cave or an active volcano. Furthermore, many of these locations are

[28] Alundra, 1997, Matrix Software Co., ltd.

inaccessible to normal people; casting further doubt on the reason of their existence and who placed the pots in their locations. However, rather than narrative, the pot serves to give feedback to the player as to what items the player can use at such times as well as give the player feedback of existing travel options that would normally be hard to see.

5.4.4.3 Narrating Descriptor

Narrating descriptors are narrators within the game with whom the player can interact. They generally serve to either tell the player something directly about the game world at large, or to give the player directions to new possible goals. Narrating descriptors in that sense do not have to be humanoid; any object that relays text to the player after interaction is a narrating descriptor.

It should be noted that when referring to narrating descriptors, we refer specifically to those descriptors the player can choose to interact with. Narrators that narrate store to the player through means the player does not have any control over should be considered normal narrators and not narrating descriptors.

Figure 5-7 Chrono Cross

In Chrono Cross[29], the player is required to converse with non-playable characters in the game world [Figure 5-7]. This is necessary to receive hints about future goals, optional quests the player can undertake or to recruit various characters in the game world into the player's own party of characters.

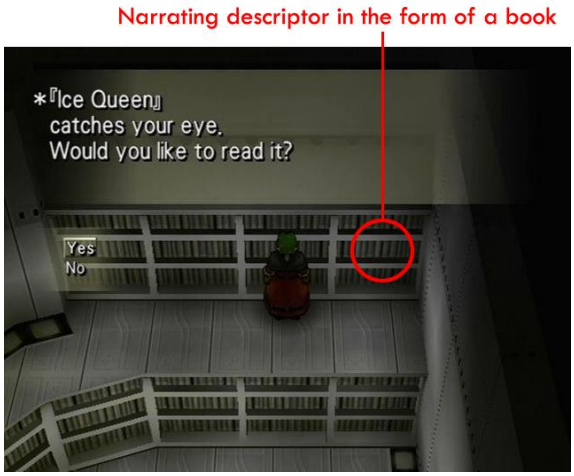


Figure 5-8 Wild Arms 3

In Wild Arms 3[30], the player will often encounter book cases [Figure 5-8] which contain information regarding possible secrets in the game world, hints to future locations or history regarding the locale in which the player found the book. Books are just one example of non-human narrating descriptors; other examples include objects like sign boards, computer screens or other objects that in our world would be liable to contain written or spoken text.

5.4.5 Linear and Open Model

Before creating the model based on the definitions that have been established in this paper, a closer look at how game-play is structured within a game is needed. The reason for this is that the type of game-play can have an effect on the way the narrative world needs to be structured

[29] Chrono Cross, 1999, Square Co., ltd.

[30] Wild Arms 3, 2002, Sony Computer Entertainment, Inc.

as well. We can distinguish between two types of structures; the linear and open structure.

5.4.5.1 Linear Structure

The linear structure has the player going from one point to another until the player has beaten the game. The player visits each narrative space in succession and has little to no control which narrative spaces the player can visit. For that reason, descriptors are mostly limited to what information they can convey to the player. On one hand, the descriptors can be more focused on expressing narrative, but on the other hand the player's exposure to them is only very short, since players cannot get back to previously visited locales.

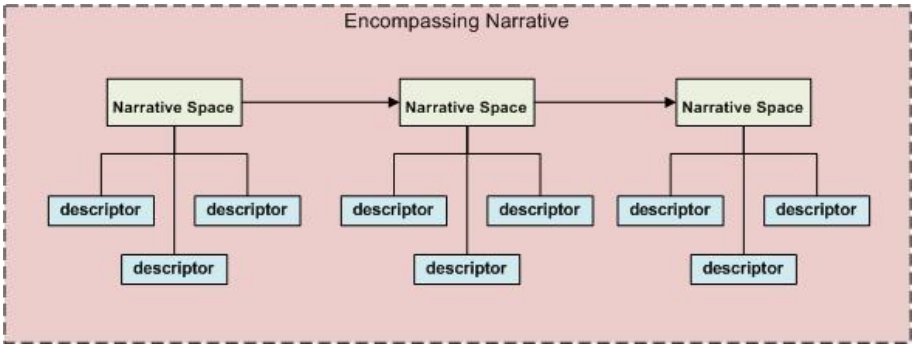


Figure 5-9 Linear Model.

5.4.5.2 Open Structure

As opposed to the linear structure, the open structure gives the player the ability to revisit previously visited locales. This in turn has an effect on how the narrative components need to be established, as the player needs to aware of their existence. This is due to the nature of the open model, which allows the players to visit narrative spaces of their own choosing. Players need to be aware to the functions of narrative spaces and the elements within them in order to gain a reason to return to them. In order to accommodate tan open structure, the open model has a need for one or more narrative HUBs in order to connect the narrative spaces together.

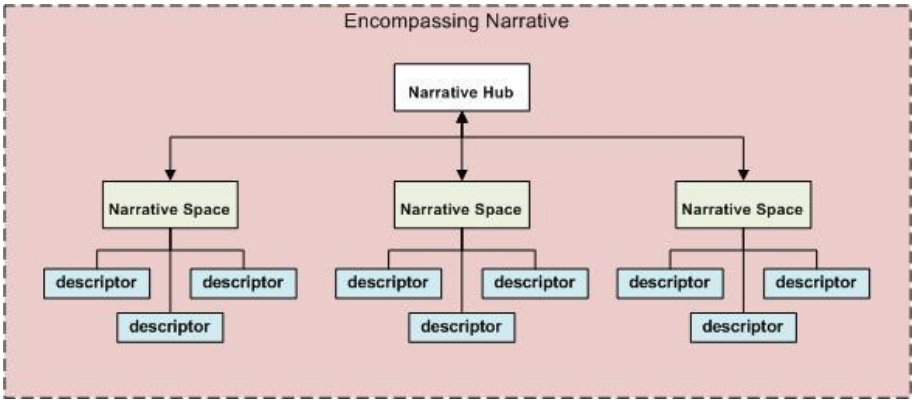


Figure 5-10 Open Model.

5.5Validation Method

5.5.1 Participants

There were a total of 15 participants, of which 9 were male and 6 were female. The average age was 27.4 years with a standard deviation of 7.06. 8 participants were of Japanese nationality, whereas the other participants had varying nationalities.

5.5.2 Equipment

The computer used for the experimental game prototype was an Intel Core i5-2400 3.1GHz, with 4.0GB RAM and a AMD Radeon HD 6450 1.00GB. The operating system used was Windows 7 Enterprise (64bits). Additional hardware to control the prototype was used in the form of a Microsoft Wireless XBOX360 Controller for Windows.

5.5.3 Preparations

An experimental prototype to contain the stimuli was designed using the Unreal Development Kit July 2012 Beta. The prototype takes the form of a side scrolling action type game, where the game camera is always fixated to the side of the environment. The user is able to move left and right, run, jump, crawl, descend or ascend staircases as well as enter doorways. Two stimuli, divided into 3 stages each, where prepared for the experiment. Each stage of the stimuli shows more details of the

environment (see table 2). For measuring the immersion levels, we used the Game Experience Questionnaire (GEQ) [32].

Stage	Stage contents
Stage 1	Basic geometric shapes, no descriptors.
Stage 2	Basic descriptors to establish basic identity of the narrative space.
Stage 3	Full narrative descriptors and narrating descriptors.

Table 5-2 Stimuli Setup.

Figure 5-11 Stimulus 1, with stage 1 to 3 (from left to right).

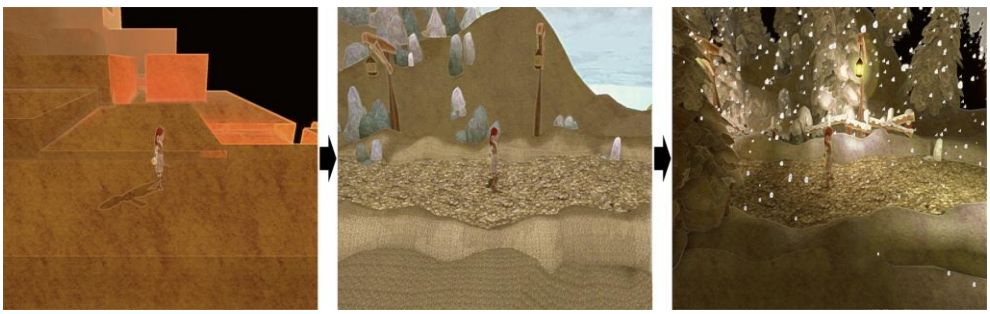


Figure 5-12 Stimulus 2, with stage 1 to 3 (from left to right).

5.5.4 Protocol Design

Users were first expected to complete a tutorial stage, to get the users accustomed to how to play the prototype. During this stage they were verbally guided by the examiner. After that, the users were required to

play through the stages in a fixed order. After every stage the user had to fill in the in-game module of the GEQ before they could continue to the next stage. After completing all the stages, the users were required to complete the core module of the GEQ.

5.5.5 Data Analysis

For the data analysis, we used the core module (which contained 31 questions) and the in-game module (which contained 14 questions) of the GEQ. The social presence module was ignored since the experimental prototype did not contain any interactions with other players. Furthermore, we decided to forego the post-game module in exchange for the core module, as the post-game module did not test immersion in-depth. The questions of the GEQ were all in Likert scale format, with the values going from 0 (not at all) to 4 (extremely). All questions were about player experience and feelings during playing the game. Out of the 7 components of the GEQ, we focused on the questions regarding sensory and imaginative immersion, flow, tension/annoyance, negative aspect and positive aspect. The other two components, namely competence and challenge, were not necessary for this particular research. Due to the limitations of the experimental prototype, we were unable to validate the functional descriptor, which is therefore not included in the data analysis.

5.6Validation Results

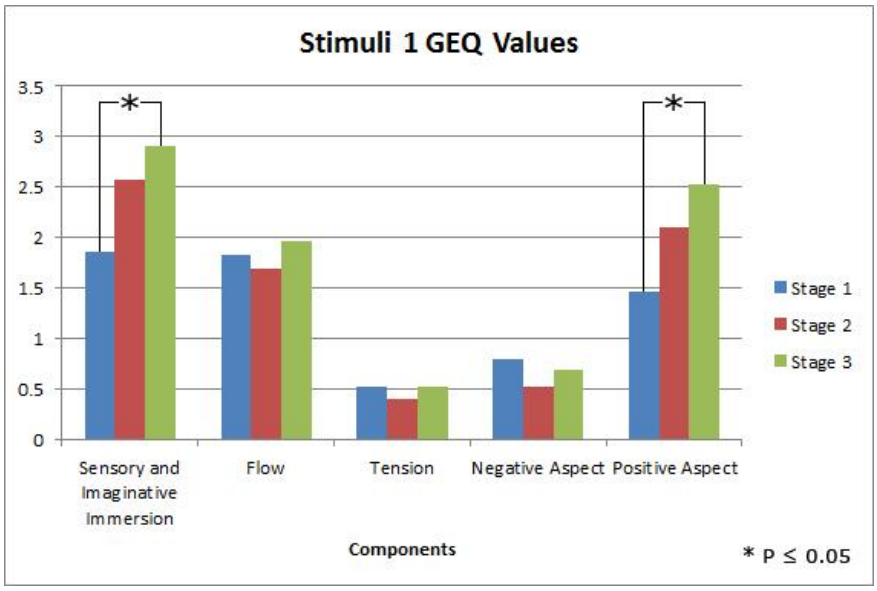


Figure 5-13 Stimuli 1 GEQ in-game module results

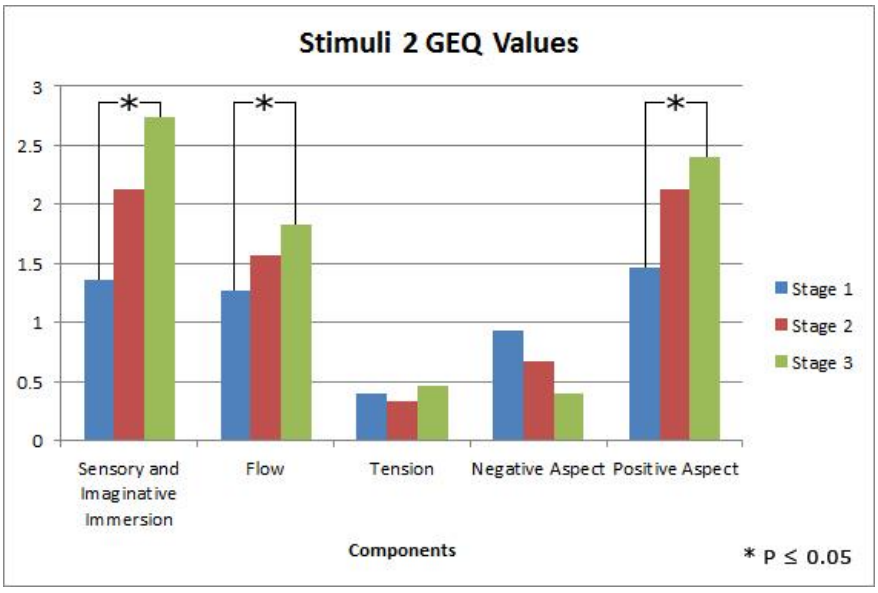


Figure 5-14 Stimuli 2 GEQ in-game module results

[Figure 5-13] and [Figure 5-14] show that when participants played the stages in the stimuli, the stages that contained the biggest variety of narrative descriptors and narrating descriptors scored significantly higher than the areas who did not. Furthermore, the positive aspect module also showed distinct differences between the areas. There was a minor

decrease in negative aspect when compared the first stage against the second stage, but the difference was not significant enough to give it any attention. Flow requires further testing. Tension scores were insignificant as well, though it can be argued that tension relates more to challenge rather than immersion, which was not the goal of this experiment.

5.7Limitations

Due to the nature of the experiment, the development of the stimuli takes a long time. A limitation of this study was that due to the allotted timeframe, we were only able to develop two stimuli. However, due to the size of the stimuli, we feel the result is still relevant, though a few elements (such as the flow component) require further validation.

6. USING COLOR TO GUIDE USERS IN DIGITAL ENVIRONMENTS

6.1 Introduction

In the previous chapter, we argued that on top of knowledge about challenge design, we also needed to address the areas in which we applied challenge design, namely the game world itself. Since the game world is a large narrative object, we defined its narrative properties in order to more effectively design game worlds. In this chapter, we expand upon that research by delving deeper in how to design the visual aspects of a good game world.

The aim of this research is to create new methods to make progression through game environments more intuitive for users of games. Our research focus is on how the user perceives the environment visually and how the user deals with this information. Past studies in interior design have proven the effectiveness of color on visitors [33] [34]. However, a weakness of these studies is that they mostly relied on the psychological effects of color, which can be argued to have different effects depending on culture. Therefore, we seek to find whether color at its most basic can influence user behavior.

We have therefore conducted two experiments and analyzed how users would perceive contrasting colors (based on the definitions found in the book Art of Color [35]) and whether these contrasts had any effect on their viewing behavior as well as decision making. The first experiment was set up to emulate a game environment. Due to limitations present within this experiment regarding luminosity analysis, as well as the size of the stimuli, we conducted a secondary experiment to eliminate the issues present within the first one and safeguard the reliability of the data.

6.2Method

6.2.1 Equipment

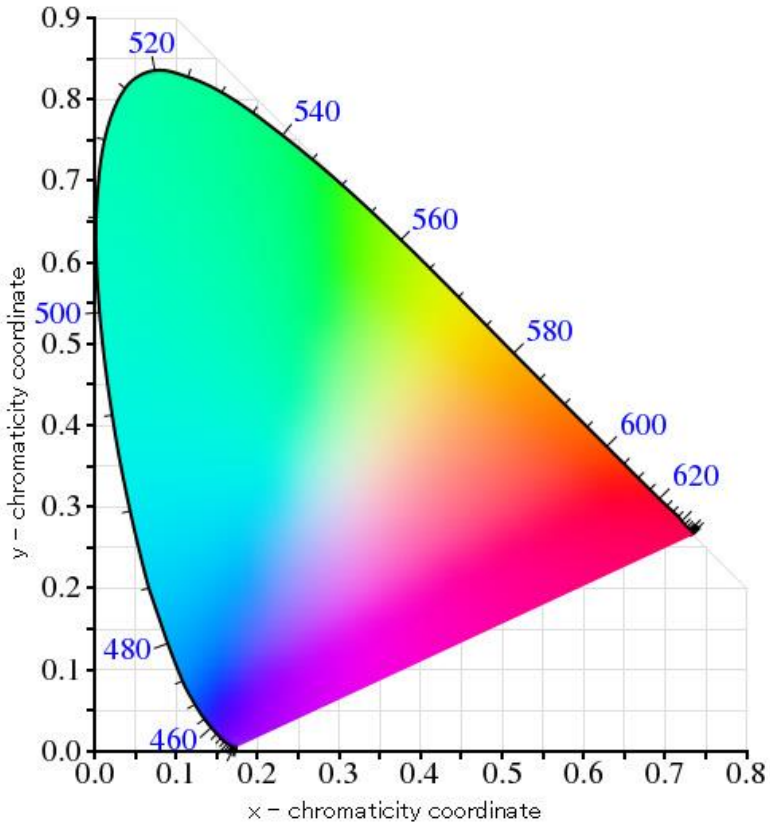


Figure 6-1 CIE1931xy chromaticity diagram, with the blue values being the color wavelengths in nanometers.

The CIE 1931 xy chromaticity space [Figure 6-1], was defined by CIE (Commission Internationale de l'Eclairage) in 1931 [36] and was the first to define the quantitative links between physical pure colors (i.e. the color wavelengths) in the electromagnetic visible spectrum, and the physiological perceived colors in human color vision. The chart shows the entire color range of what an average human eye can observe.

A BENQ G2400WDLCD monitor was used for the experiment. Using the chart in [Figure 6-1], we calculated the gamut range of the monitor, whose range is shown in [Figure 6-3] and [Figure 6-5]. The gamut range of the monitor is the possible range of colors a monitor can output, which for this

monitor is visualized by the area within the triangle with the red outline. [Figure 6-3] and [Figure 6-5] also show the xy positions of the values of the color circles being used. For the two CMYK values (CYY and Y) that reported one or more of the RGB values to be more than 255 (i.e. outside of the gamut range of the monitor), we used the max value of 255.

We experimented with two different color circles. The first color circle was based on CMYK values, to closely emulate the color circle that Itten, J., used in his experiments. The second color circle was based on RGB values, using the same means of creating the color circle as the CMYK circle. The CMYK circle was used for both experiments, whereas the RGB circle was primarily used for the second experiment.

For the paints used to construct the CMYK color values, we used the Holbein Artists Gouache G651 Primary Magenta, Holbein Artists Gouache G652 Primary Yellow and Holbein Artists Gouache G654 Primary Cyan. We used 218GSM paper for the color samples. To convert the colors to waveform values, the Konica Minolta CM2600d spectrometer was used. Recordings were made using the SAV setting while using F2 light source data. Since the experimental prototype was designed on a digital platform, there was a need to convert the color waveform values to digital values. To do this, the Konica Minolta Spectroradiometer CS-1000 was used. The colors were converted to hexadecimal values for usage in the experimental prototype.

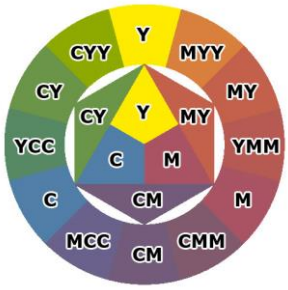


Figure 6-2 The CMYK color circle (colors have been coded with uppercase letters).

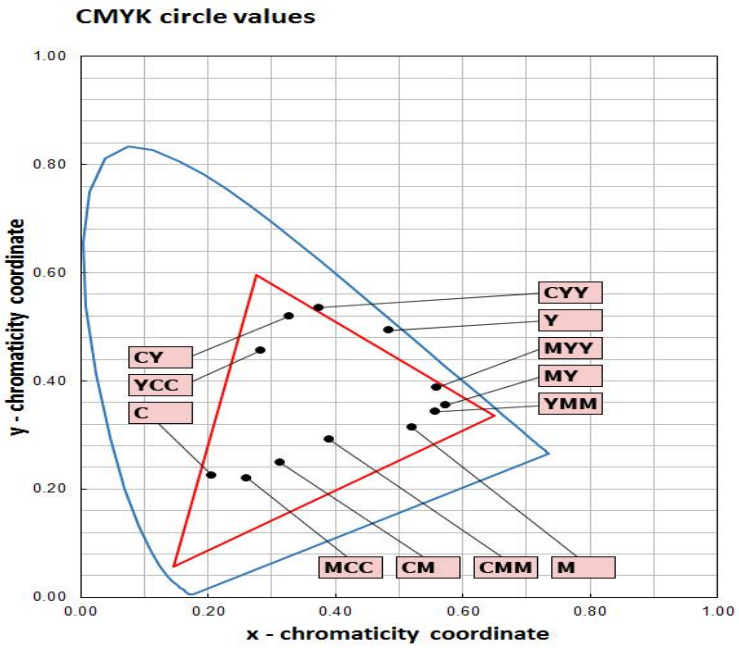


Figure 6-3 BENQ G2400WDLCD gamut range, including used CMYK values.

Color Code	Color mixture	R	G	B	Hexadecimal
C	Cyan (C)	80	126	186	507E8A
Y	Yellow (Y)	255	235	0	FFEB00
M	Magenta (M)	170	84	99	AA5463
CYY	C(25%) Y(75%)	142	170	0	8EAA00
CY	C(50%) Y(50%)	107	149	72	6B9548
MYY	M(25%) Y(75%)	217	128	61	D9803D
MY	M(50%) Y(50%)	195	97	75	C3624B
CMM	C(25%) M(75%)	129	91	109	815B6D
CM	C(50%) M(50%)	114	92	123	725C7B
MCC	M(25%) C(75%)	106	98	140	6A628C
YMM	Y(25%) M(75%)	181	90	83	B55A53
YCC	Y(25%) C(75%)	87	137	99	578963

Table 6-1 Digital CMYK color values used for the experimental prototype.

Furthermore, the first experiment had as a limitation that it only used the CMYK colors to check whether color could influence the behavior of the participants, since the color circle developed by Itten J., was also based on print colors. Since monitors primarily use RGB values instead of CMYK, using a color circle not native to a digital environment could be construed as a limitation of the study. For this reason, we opted to include an alternate color circle based on RGB values for this experiment, so we could analyze whether there was a difference of effects between the CMYK and the RGB based color circles.

However, the construction of the color contrasts of Itten, J. are heavily dependent on the color values of the three primary colors. If these color values are not properly imitated, we will become unable to create the hot and cold contrast, complementary contrast and the contrast of hue (see chapter 6.2.2 for more information). For that reason, even though we are using RGB values, we have converted the G (green) value to the highest yellow value present in RGB. Using the new primary RGB values as a base, we have mixed the secondary and tertiary colors according to the same proportions as the CMYK values.

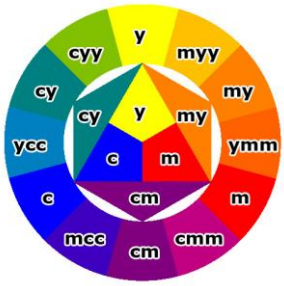


Figure 6-4 The RGB color circle (colors have been coded with lowercase letters).

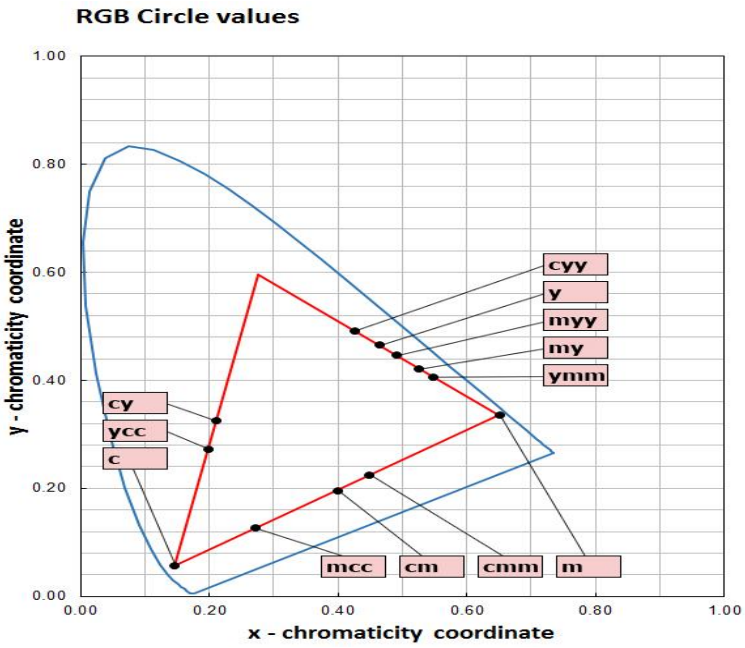


Figure 6-5 BENQ G2400WDLCD gamut range, including the used RGB values.

Color Code	R	G	B	Hexadecimal
c	0	0	255	0000FF
y	255	255	0	FFFF00
m	255	0	0	FF0000
cyy	128	192	0	80C000
cy	0	128	128	008080
myy	255	192	0	FFC000
my	255	128	0	FF8000
cmm	192	0	128	C00080
cm	128	0	128	800080
mcc	64	0	192	4000C0
ymm	255	96	0	FF6000
ycc	0	128	192	0080C0

Table 6-2 Digital RGB color values used for the experimental prototype.

To get colors mixed with black and white for either circle, we overlaid an additional layer of black or white over the colors of the color circles and adjusted the transparency as needed.

The computer used for the experiment was an Intel Core i5-2400 3.10GHz, with 4.0 GB RAM and an AMD RADEON HD 6450 1.00GB. The operating system used was Windows 7 Enterprise (64 bits). Additional hardware to control the experimental prototype was used in the form of a Microsoft Wireless XBOX360 Controller for Windows. For the eye tracking hardware, we used a Mirametrix S2 eye-tracker, model MRS2.

6.2.2 Color Contrast Preparation

For this experiment, 5 contrasts will be reviewed. Those are the hot and cold contrast, the complimentary contrast, the saturation contrast, the light and dark contrast and the contrast of hue.

6.2.2.1 Hot and Cold Contrast

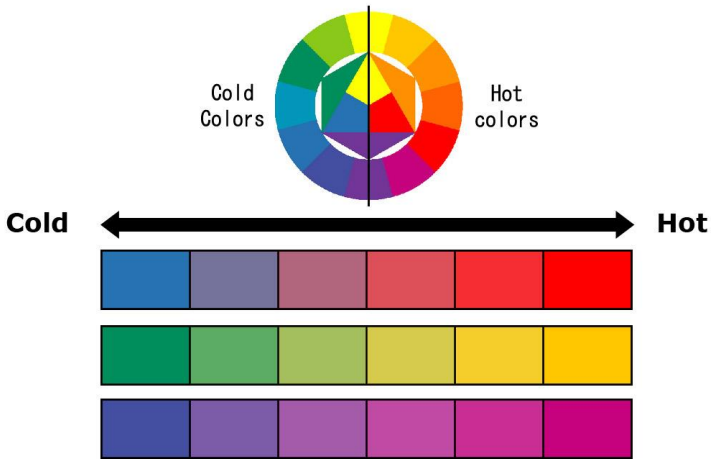


Figure 6-6 Hot and cold contrast.

To determine which color is considered hot and which color is considered cold, the color circle is split in half. Every color on the right side of the color circle is considered to be a hot color, whereas everything on the left side of the circle is considered a cold color.

6.2.2.2 Complementary Contrast

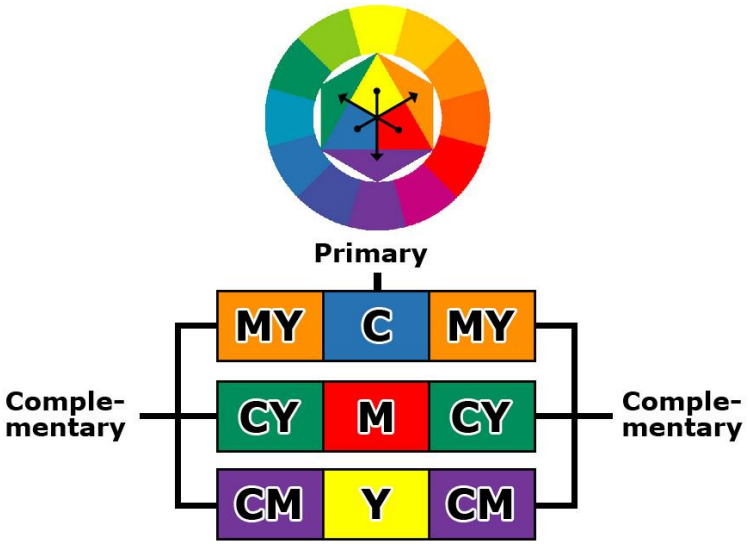


Figure 6-7 Complementary Contrast.

Within a complementary contrast, a primary color (the inner triangle of three colors) are combined with the secundary color (gotten by mixing two primary colors) that are polar opposite of them. According to Itten, J., the secundary color will strengthen the primary color.

6.2.2.3 Saturation Contrast

Figure 6-8 Saturation contrast.

The contrast of saturation relies on the purity of a color. The more a color is mixed down, the less saturated it becomes. A saturation contrast relies

on the difference between a more saturated color and a less saturated color.

6.2.2.4 Light and Dark Contrast

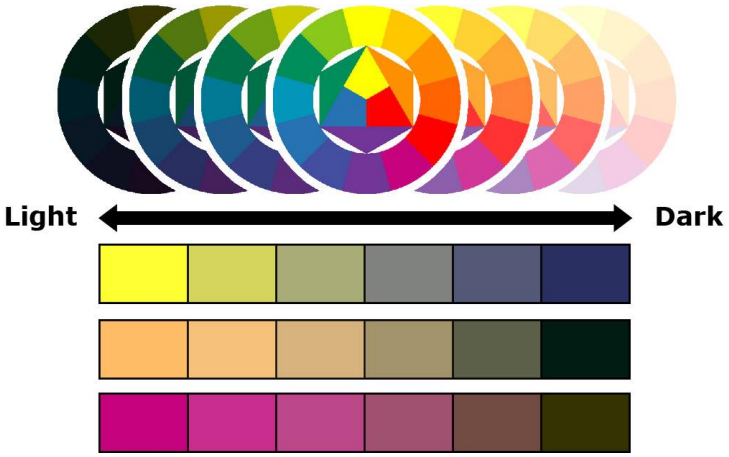


Figure 6-9 Light and dark contrast.

For the light and dark contrast, a color is mixed with either dark or light colors (generally black or white) to make it lighter or darker.

6.2.2.5 Contrast of Hue

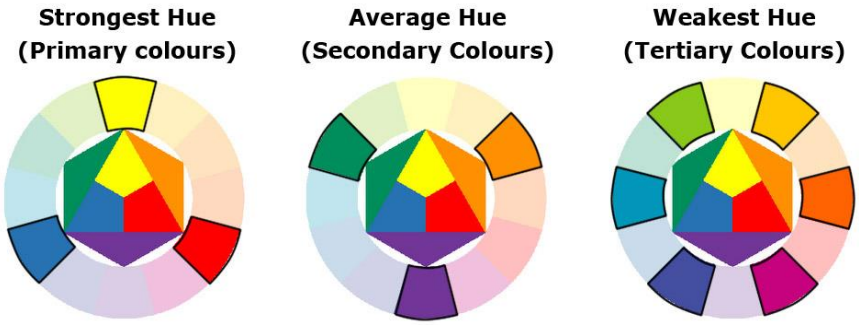


Figure 6-10 Contrast of hue.

According to Itten, J., the closer a color was to being a primary color, the stronger it was. A primary color is a color that cannot be gotten through mixing colors. Secondary colors are created by mixing two primary colors with one another. To get tertiary colors, a secondary color needs to be mixed with a primary color. For this reason, in this contrast, the primary

colors are the strongest hue whereas the tertiary colors are the weakest. Secondary colors are of average strength.

6.3Monochrome versus Color Experiment

6.3.1 Goal of the Experiment

The goal of this experiment was to determine whether there was a difference in user behavior between participants that had to choose between color coded elements or participants that had to choose between elements that were monochrome.

6.3.2 Method

6.3.2.1 Participants

Two experiments were conducted, with 12 participants each. For the first experiment, the average age of the participants was 28.6 with a standard deviation of 7.3. There were a total of 6 females and 6 males. For the second experiment, the average age of the participants was 26.2 with a standard deviation of 3.9. There were a total of 5 females and 7 males. For both experiments the participants were of varying nationalities.

6.3.2.2 Preparation

An experimental prototype to contain the stimuli was designed using the Unreal Development Kit July 2012 Beta. The stimuli can be found in [APPENDIX A]. The prototype takes the form of a side scrolling action type game, where the game camera is always fixated to the side of the environment. The prototype features only the most basic controls to allow for interaction with the environment. The user is able to move left and right, run, jump and crawl. The player can also descend or ascend staircases as well as enter doorways, but this process is automated once the player confirms the start of the process through a press of a button.
Two sets of stimuli were prepared. The first set was designed to have the 5 contrasts we are going to review. The second set of stimuli was a copy of the first set, but with the colors entirely removed to create monochrome rooms. 3 stimuli were prepared for the complementary contrast and the

contrast of hue. For the hot and cold contrast, the saturation contrast and the light and dark contrast 4 stimuli each were prepared. Furthermore, a tutorial room and a finish room were prepared as well.

6.3.3 Protocol Design

Experiments were conducted in a well lit room, whose settings could be adjusted if there was a need for it. Participants were requested to not wear glasses or make-up, due to interference with the eye-tracking hardware.

Participants were first explained the contents of the experiment, after which the examiner would proceed to calibrate the eye-tracking hardware. In order to get accustomed to the controls, participants would first play a tutorial room in which the examiner explained how to operate the XBOX360 controller. After the tutorial room was finished, the participants would be assigned either the monochrome or the color stimuli.

The stimuli would appear in randomized order, until the participant had finished all the stimuli after which the participant would be taken to the finish room. Once the participant had reached the finish room, they were required to fill in a questionnaire to make up for lacking data.

6.3.4 Data Analysis

Out of the five contrasts used for the experiment, we were able to establish goals for two. Both the complementary contrast as well as the contrast of hue was clearly defined by Itten, J. With the complementary contrast, a primary color gets strengthened by its complementary color, meaning that the entrances containing the complementary contrast as opposed to those who do not are considered the goals. Furthermore, in the contrast of hue it is regarded that the more pure a color is, the stronger it becomes. That means that a primary color is dominant over a secondary color and a secondary color is dominant over a tertiary color. For the remaining contrasts however, there was not a clear definition, so we will conclude their effects by the frequency of entrances being chosen.

To analyze eye tracking data, we will be making use of areas of interest (AOI). These are areas that are predetermined as areas where we want to

know whether the player is going to look at it. Since certain stimuli designed for the experiment are bigger than what can be seen on the screen, the game camera that allows us to see the game environment moves with the player character. Since this creates movement, which will constantly shift the position of the areas of interest relative to the position of the game camera, we are required to use dynamic AOIs, which are AOIs that move.

A typical fixation is anywhere between 200-300ms, whereas saccades and glissades are only 30-80ms and 10-40ms respectively [37]. Therefore, everything below 200ms was not considered a fixation, but a saccade or glissade instead. This data was not included in the analysis, as the main focuses are the average and total dwell-times of the AOIs. Furthermore, eye tracking data after the player had made a choice was not recorded either; as the data that leads up to the decision is the only data that we needed. We consider a decision to be made the moment the player has pressed the button to proceed to the next room, as this action cannot be undone since the act of entering entrances is automated. Once the transition between two rooms is finished, if the player's gaze happened to be inside of an area of interest, but hadn't moved since before the transition was finished, the gaze is not considered to be a hit, but a coincidence.

ANOVA was used to analyze the significance of the dwell data, whereas Wilcoxon Paired Signed Rank Test was used to analyze the significance of the choice data between the monochrome and colored stimuli.

6.4Experiment 1 Color Contrast Analysis

6.4.1 Hot and Cold Contrast

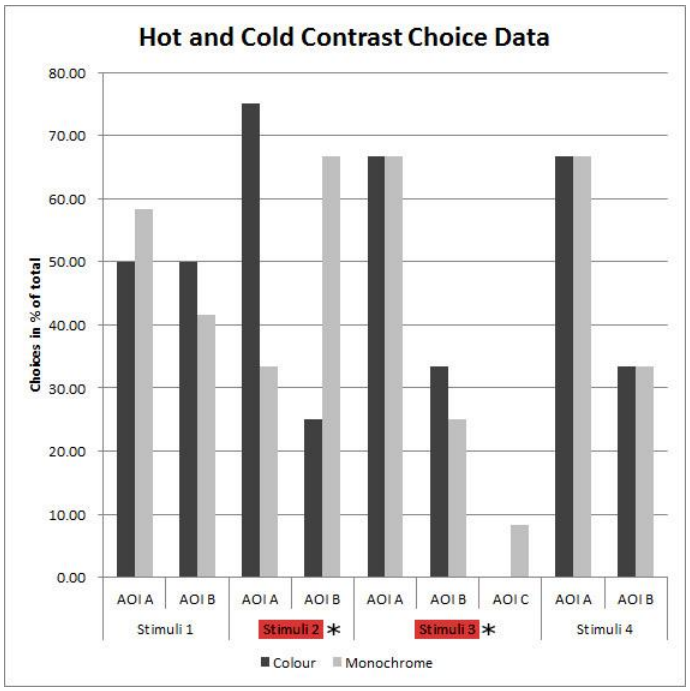


Figure 6-11 Hot and Cold contrast choice data. *P < 0.05

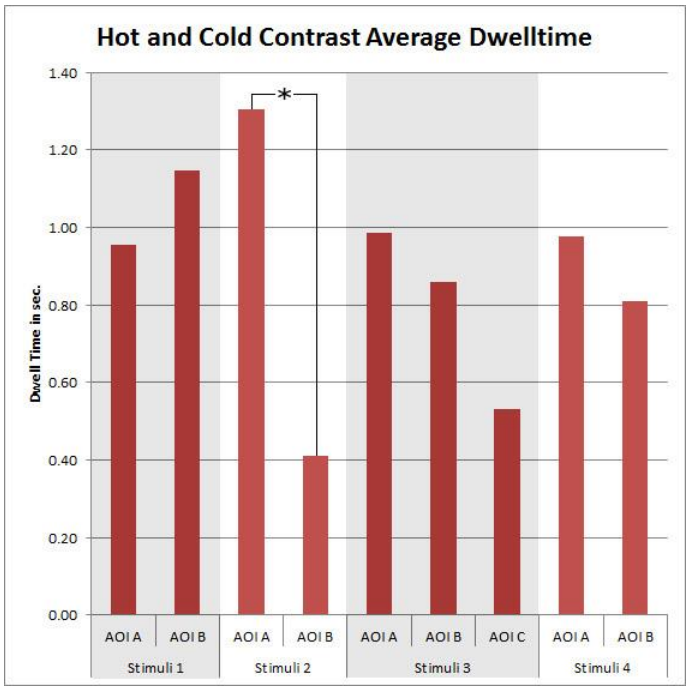


Figure 6-12 Hot and Cold contrast average dwell-time. *P < 0.05

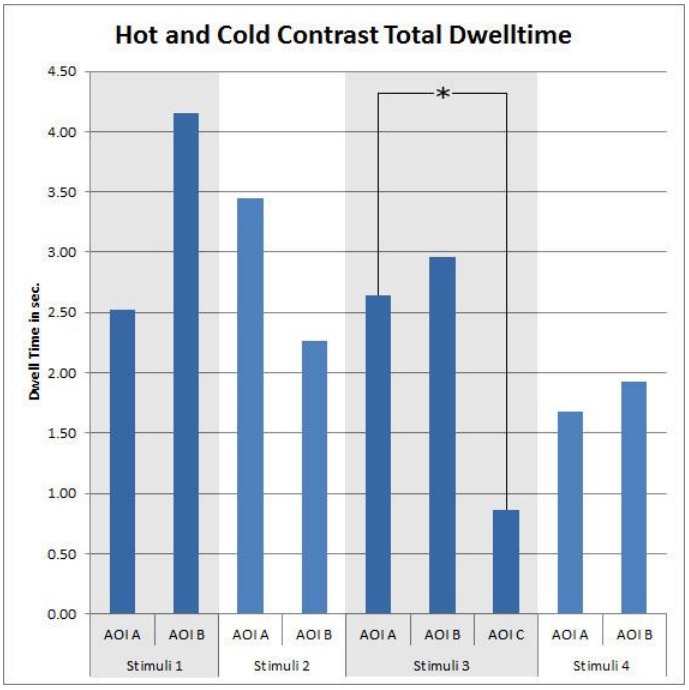


Figure 6-13 Hot and Cold contrast total dwell-time. *P < 0.05

The hot and cold contrast performs rather poorly, with no distinct preference given for either the hot or cold color, in terms of dwell times, with only the second stimuli (for average dwell-time) and the third stimuli (for total dwell-time) returning a significant difference. Regarding the choice data, the second stimuli is of interest, as the choices made in the colored and monochrome samples are almost reversed. Stimuli 3 is of lesser interest, as while it turned out to be significant, the results of both the monochrome and the color stimulus are almost identical.

6.4.2 Complementary Contrast

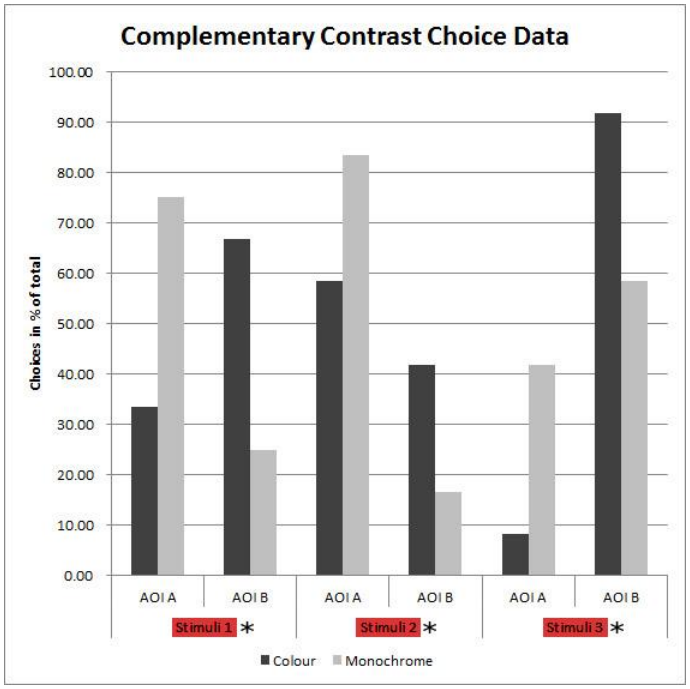


Figure 6-14 Complementary contrast choice data. *P < 0.05

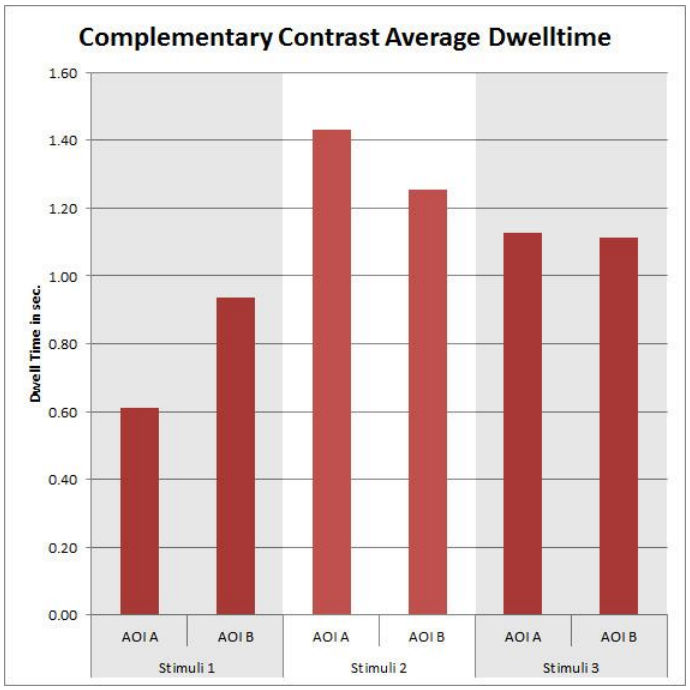


Figure 6-15 Complementary contrast average dwell-time. *P < 0.05

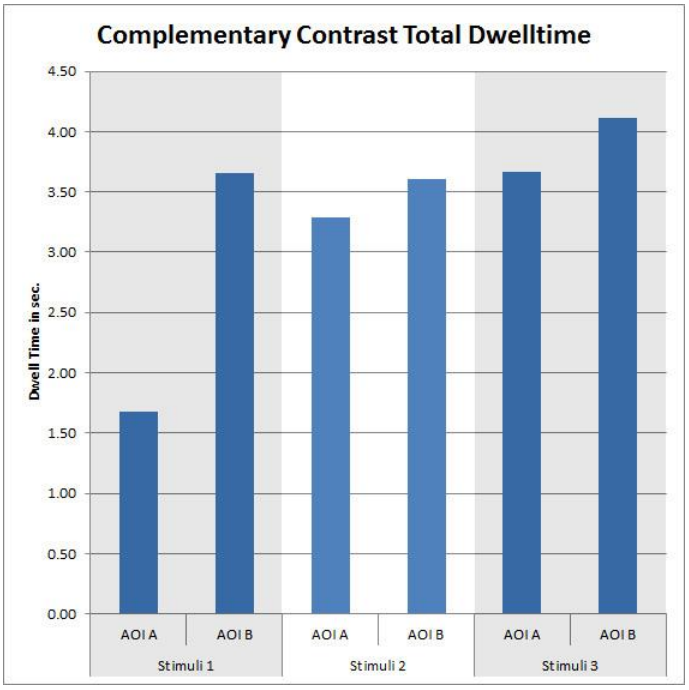


Figure 6-16 Complementary contrast total dwell-time. *P < 0.05

The complementary contrast gave rather curious results. Whereas both the average dwell-times and the total dwell-times didn't return any significant results, the choice data for all 3 stimuli gave significant differences between both the monochrome and the colored stimuli. As for the colored stimuli, the contrasts behaved rather unexpectedly, as the choice data of the colored stimuli gave results that were opposite to the expectations set by Itten, J.

6.4.3 Saturation Contrast

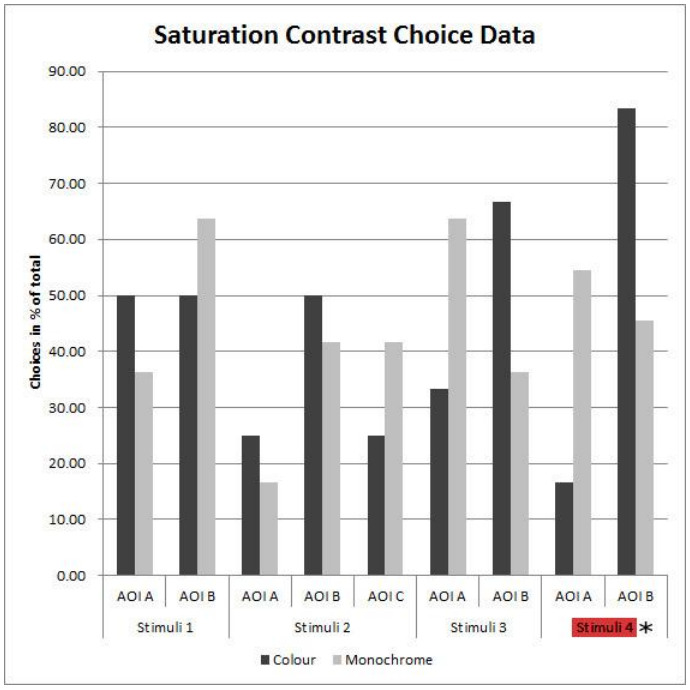


Figure 6-17 Hot and Cold contrast choice data. *P < 0.05

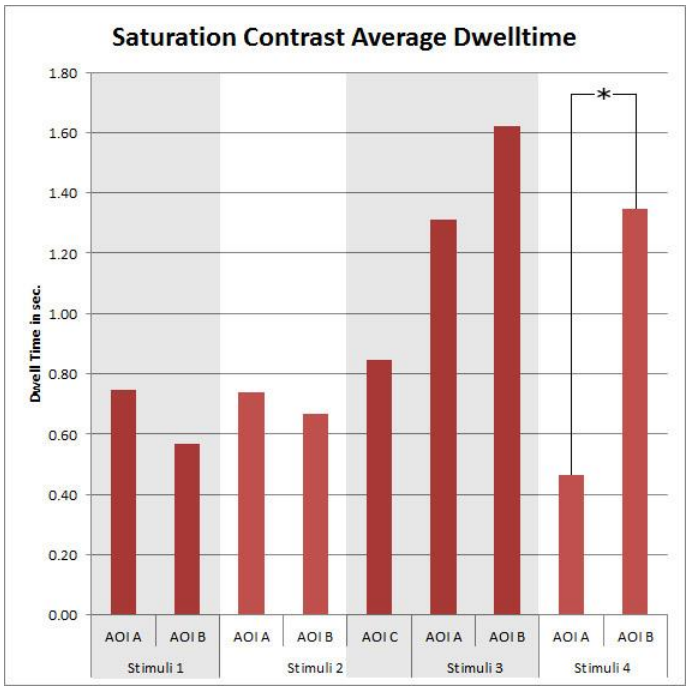


Figure 6-18 Hot and Cold contrast average dwell-time. *P < 0.05

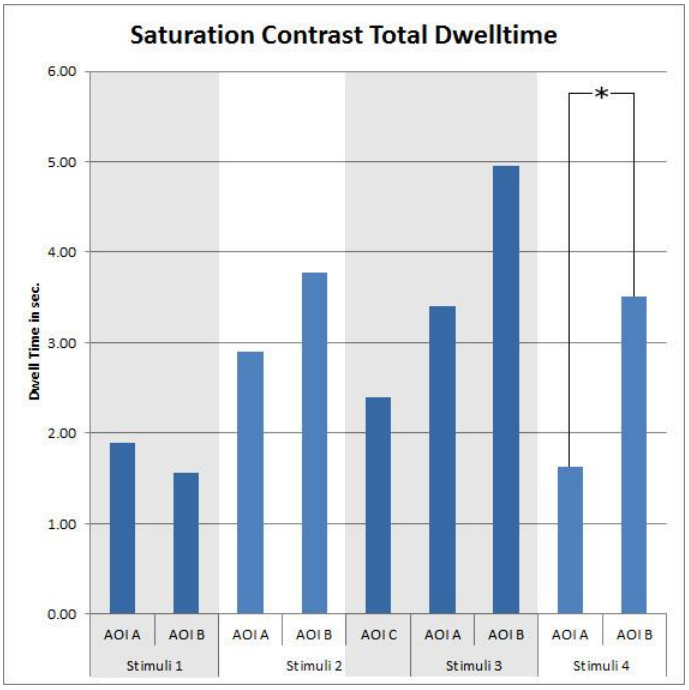


Figure 6-19 Hot and Cold contrast total dwell-time. *P < 0.05

The 4th stimulus of the saturation contrast was the first stimulus to return a significant value on both dwell-times and decision making. Overall for the colored stimuli, there is a preference towards the more saturated colors as opposed to the unsaturated colors. While the decision making of first stimulus was 50% for either area of interest, both the average and total dwell times on the more saturated color of the first stimulus was higher than that of the unsaturated color.

6.4.4 Light and Dark Contrast

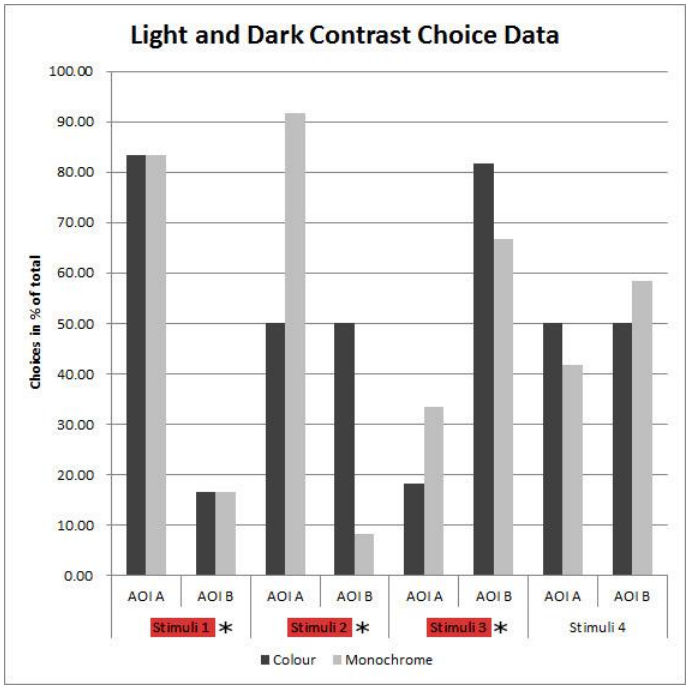


Figure 6-20 Light and Dark contrast choice data. *P < 0.05

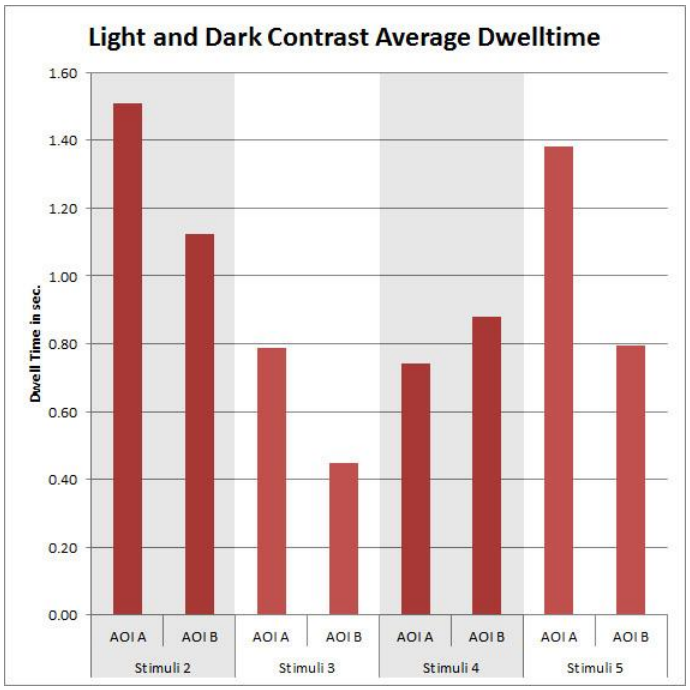


Figure 6-21 Light and Dark contrast average dwell-time. *P < 0.05

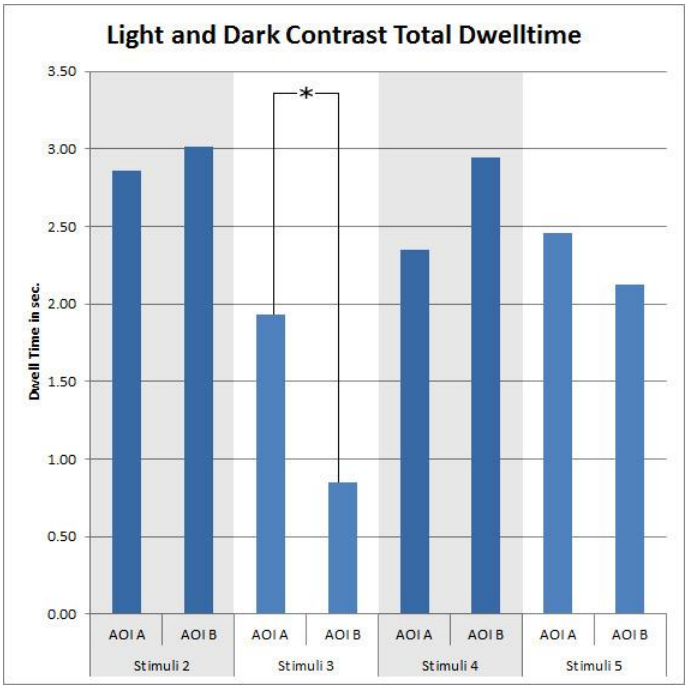


Figure 6-22 Light and Dark contrast total dwell-time. *P < 0.05

In regards to decision making, the majority of the stimuli return a significant value, though looking at the choice data also reveals that the differences in decision making between the colored and monochrome stimuli were largely non-existent. In regards to the colored stimuli, the light and dark contrast performs okay. While dwell-times were largely insignificant, the reported average and total dwell times on the stimuli are in favor of the lighter colors as opposed to the darker colors, for all stimuli apart from the fourth stimulus.

6.4.5 Contrast of Hue

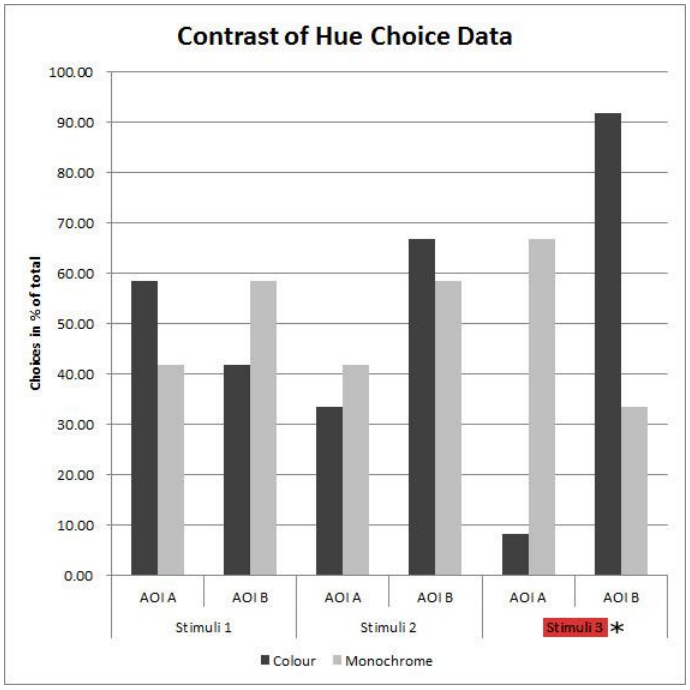


Figure 6-23 Contrast of hue choice data. *P < 0.05

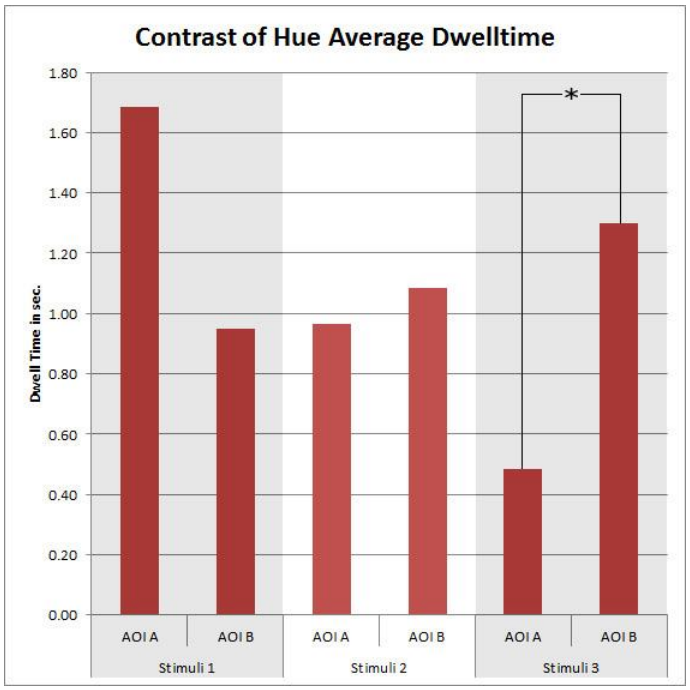


Figure 6-24 Contrast of hue average dwell-time. *P < 0.05

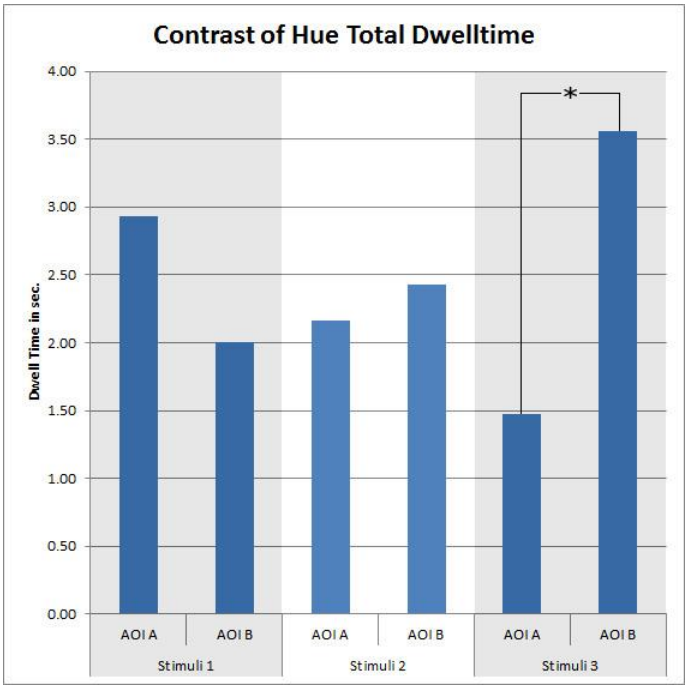


Figure 6-25 Contrast of hue total dwell-time. *P < 0.05

The contrast of hue performed poorly though, like the saturation contrast, one of the stimuli returns a significant value on both dwell-times and decision making. Furthermore, the colored stimuli behaved contrary to the expectations set by Itten, J.

6.5Limitations Experiment 1

A limitation of this experiment was that it relied on CMYK values, using paints that were not necessarily a standard themselves. This created a unique color circle that would not necessarily be usable by designers. CMYK colors also translate poorly to a digital screen, often with the colors losing the radiance they had when they were painted on paper.

Furthermore, there were a few issues with the stimuli that became apparent after data analysis. The first problem is that the size of the stimuli made it required for the game camera to move with the player character. This forced us to make use of dynamic areas of interest and due to the limitations of the analysis software, we had to analyze the recorded videos instead. This caused the accuracy of the data to lessen. The second problem was that even though the stimuli are design to emulate an actual game environment, their designs made it hard to use their luminance

values to create luminance contrasts to determine whether those have an effect on the players' behavior. It also caused a lot of noise in the data, which made it harder to determine reasons for particular player behavior. Lastly, for both the monochrome as well as the color part of the experiment, we had a distinct lack of participants that were left handed (83.3% and 91.7% respectively were right handed). Therefore, we could not properly conclude whether the handedness of participants had any influence on their decision making.

6.6 Color Contrast and Luminance Experiment

6.6.1 Goal of the Experiment

In order to address the concerns of the prior experiment, the second experiment was set up to eliminate 2 key issues present within the first. More specifically, we specifically addressed the camera issue and the stimuli size issue in order to improve on accuracy of eye tracking data. Furthermore, we also took the opportunity to implement a color circle based on RBG values, which are closer to screen values, in order to see whether the different color circles had any varying effects on user behavior. Thanks to the compact design of the stimuli, we were able to determine the luminance values of the stimuli, which were used to create 4 conditions by which we analyzed the effects of luminance on user behavior. 1 condition relied on the height of the luminance values, whereas the other conditions contrasted various areas of interest against one another to see whether luminance contrast had any effect on user behavior.

6.6.2 Method

6.6.2.1 Participants

The experiment was conducted with a total of 15 participants. The average age of the participants was 27.4 years, with a standard deviation of 7.1. There were a total of 9 males and 6 females. The participants were from varying nationalities.

6.6.2.2 Preparation

For each contrast, we will use 2 sets of 3 stimuli (3 stimuli of each color circle). The remaining two color contrasts, namely the simultaneous contrast and the contrast of extension, shall not be reviewed. The simultaneous contrast relies on optical illusions which can be argued whether this constitutes as a proper contrast. The contrast of extension, according to Itten, J., was dependent on each individual's personal preference.

In order to house the stimuli, an experimental prototype was designed using the Unreal Development Kit July 2012 Beta. The prototype takes the form of a side scrolling action type game, where the game camera is always fixated to the side of the environment. The in-game camera always remains stationary. The prototype features only the most basic controls to allow for interaction with the environment. The user is able to move left, right and run. The player can enter doorways, but this process is automated once the player confirms the start of the process through a press of a button. Furthermore, the player is able to jump and crawl, but these actions are not necessary in order to complete the experimental prototype.

30 stimulus rooms were prepared, for a total of 6 stimuli per contrast. Of these 6 stimuli, 3 use the CMYK circle and 3 stimuli use the RGB circle. Each stimulus room has got two entrances the participant can choose from. The entrances are surrounded by one of the colors of a particular color contrast, which have also been designated as the AOIs. Furthermore, a tutorial room and a finish room were prepared as well.

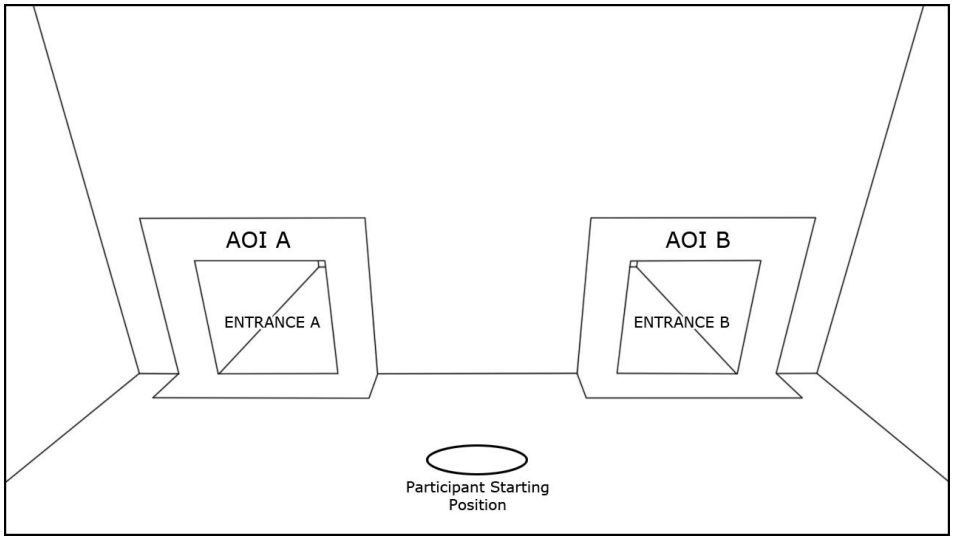


Figure 6-26 Stimulus room setup

[Table 6-3] shows how the colors of the AOIs were set up.

Contrast	**AOI A**	**AOI B**
Hot and Cold	Hot color	Cold color
Complementary	Primary color	Complementary color
Saturation	Most saturated color	Least saturated color
Light and dark	Lightest color	Darkest color
Hue	Strongest hue	Weakest hue

Table 6-3 AOI color setup.

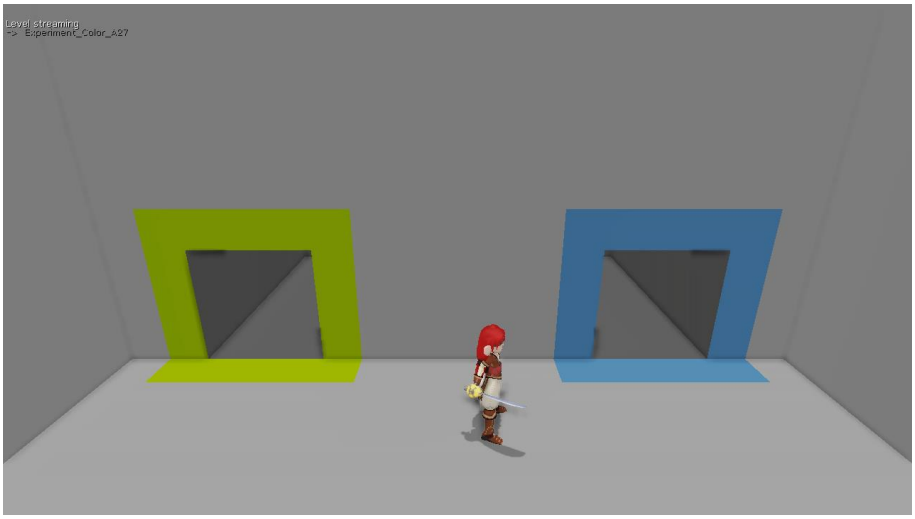


Figure 6-27 In-game screenshot of the experimental prototype.

6.6.3 Protocol Design

Experiments were conducted in a room lit by white TL lighting. Depending on the circumstances, lights were turned on or off to get a good result during the calibration of the eye-tracking hardware. Participants were requested not to wear glasses or make-up, due to interference with the eye-tracking hardware.

Participants were explained the contents of the experiment, after which the examiner would proceed to calibrate the eye-tracking hardware. In order to get accustomed to the controls, participants would first play a tutorial room during which the examiner explained how to operate the XBOX360 controller. After the tutorial room was finished, the participants would move onto the stimuli.

The stimuli would appear in a randomized order (with the position of AOI A and AOI B being randomized as well), until the participant had finished all of them. After finishing all of them, the participant would be taken to the finish room. At this point, the participant was required to fill in a questionnaire to inform about their color preferences. Once the questionnaire was finished, the experiment was concluded.

6.6.4 Data Analysis

Out of the five contrasts used for the experiment, we were able to establish goals for two. Both the complementary contrast, as well as the contrast of hue was clearly defined by Itten, J. For the complementary contrast, we defined the goal as the entrance that had the primary color as opposed to the entrance that had the secondary color. Furthermore, in the contrast of hue it is regarded that the more pure a color is, the stronger it becomes. That means that a primary color is dominant over a secondary color and that a secondary color is dominant over a tertiary color. For the remaining contrasts however, there was not a clear definition, so we will conclude their effects by the frequency of which entrances are being chosen.

For the analysis of the effects of luminance on player behavior, we created 4 conditions. The first condition analyzed the effects of the height of the

luminance values on the total and average dwell times of the user. For the other condition, we used the luminance values as contrasts and contrasted various areas to one another to determine whether luminance contrast had any effect on user behavior.

To analyze eye tracking data, we will be making use of AOI's. The stimuli were designed with a fixed game camera, which means it is not influenced by the movement of the player character. This enables us to use normal AOI's and enable us to use the raw data provided by the Mirametrix eye-tracker, which is recorded at 60 frames per second.

To determine what constituted as a fixation, the factory settings of the Mirametrix Eye-tracker were used. Like with the initial experiment, everything below 200ms was not considered a fixation but a saccade or a glissade instead. This data was not included in the analysis, as the main focuses are the average and total dwell times of the AOIs, for which fixations were necessary. Furthermore, eye-tracker data created after the player had made a choice was not recorded either; as the data that leads up to the decision was all we needed. We consider a decision to be made the moment the player has pressed a button to proceed to the next room, as this action is irreversible and the act of entering a room is automated. Once the transition between two rooms is finished, if the player's gaze happened to be inside of an AOI but had not moved since before the transition was finished, the faze is not considered a hit, but a coincidence.

Samples that were returned as invalid by the eye-tracker were not used for the analysis of the data. On top of that, it was found that the RGB values on 6 stimuli were erroneous, making it hard to determine whether they could still constitute as a contrast. While they will be considered for future luminosity analysis, they will be ignored for the current analysis.

ANOVA was used to analyze the significance of the eye-tracking data, whereas the Wilcoxon signed-rank test was used to determine the significance of the choice data. For both tests data that had a p-value of less than 0.15 was considered insignificant.

6.7Experiment 2 Color Contrast Analysis

6.7.1 Hot and Cold Contrast

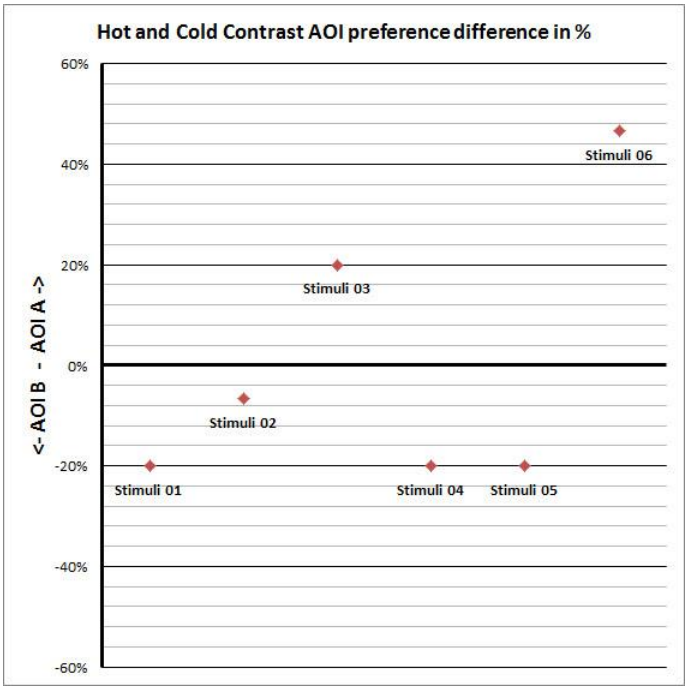


Figure 6-28 Hot and cold contrast choice data.

Stimulus	AOI A	AOI B
1	M	C
2	MY	CY
3	YMM	MCC
4	m	c
5	cmm	cyy
6	myy	mcc

Table 6-4 Hot and cold contrast stimuli colors.

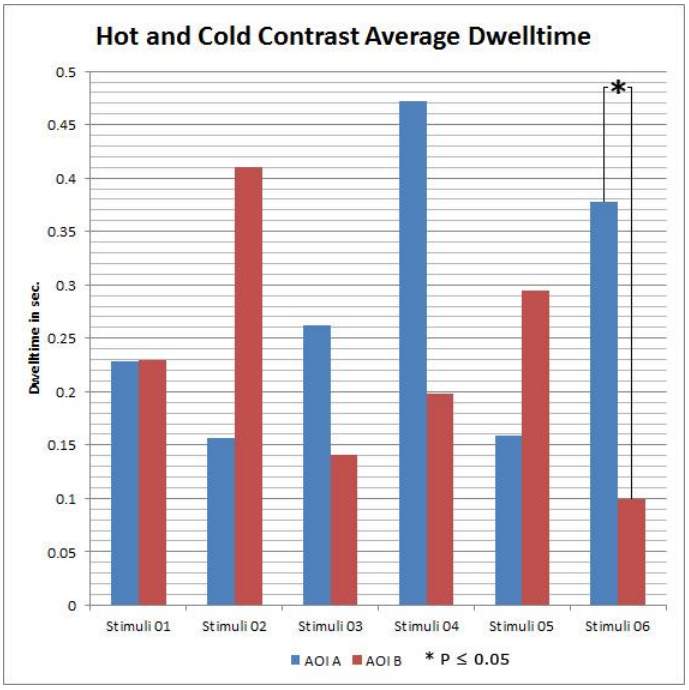


Figure 6-29 Hot and cold contrast average dwell-time data.

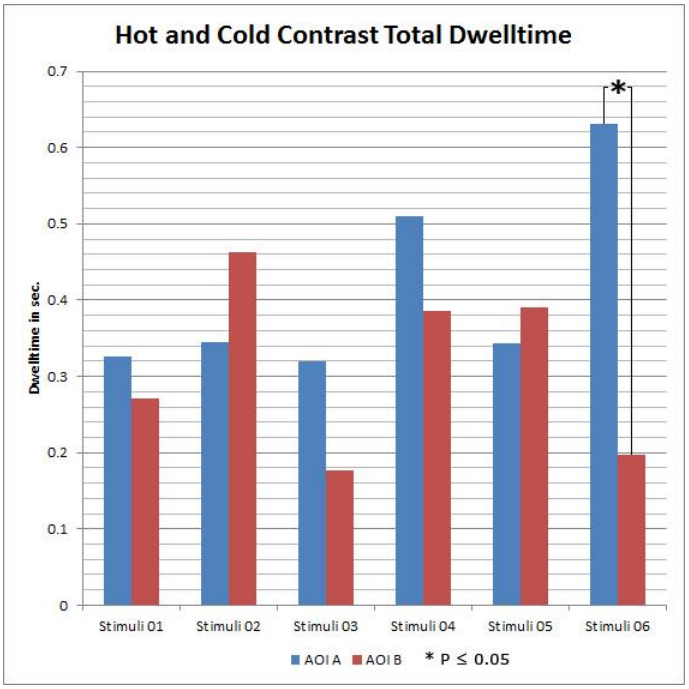


Figure 6-30 Hot and cold contrast total dwell-time data.

While, with the exception of 1 stimulus, the effects of the hot and cold contrast can be largely considered insignificant, there was a slight preference towards warm colors, in both the decision making as well as in

dwell times. In both instances, the RGB based stimuli show more difference in performance as compared to the CMYK based stimuli, whose differences between AOI A and AOI B are largely minor.

6.7.2 Complementary Contrast

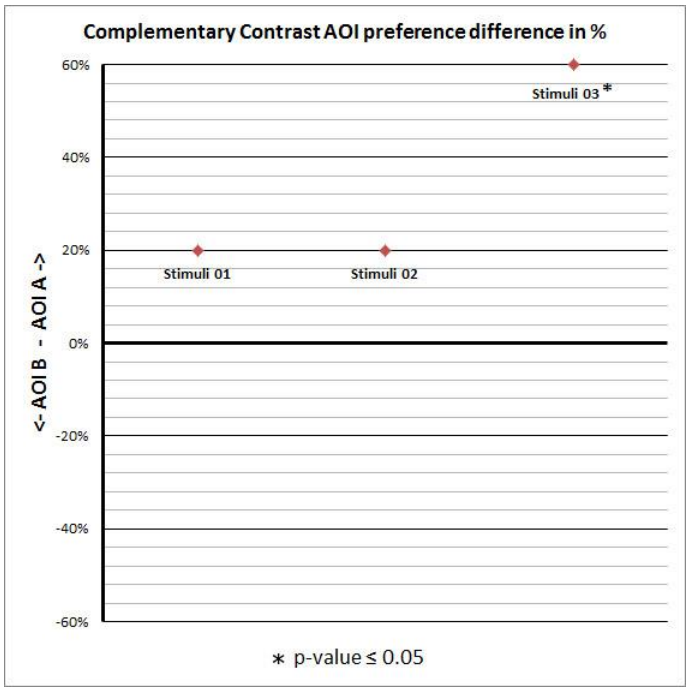


Figure 6-31 Complementary contrast choice data.

Stimulus	AOI A	AOI B
1	M	CY
2	C	MY
3	Y	CM

Table 6-5 Complementary contrast stimuli colors.

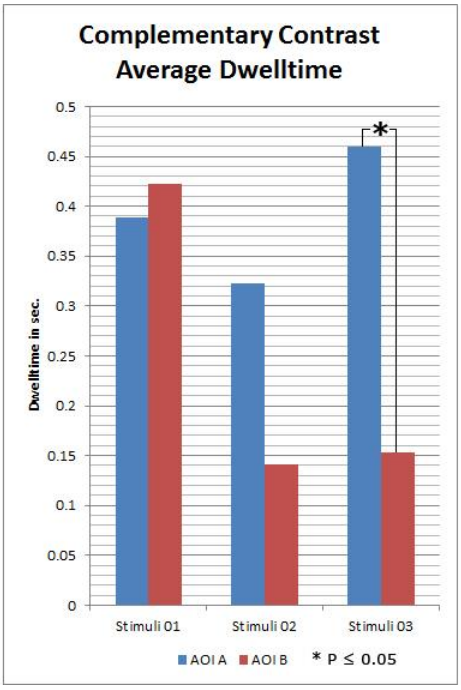


Figure 6-32 Complementary contrast average dwell-time data.

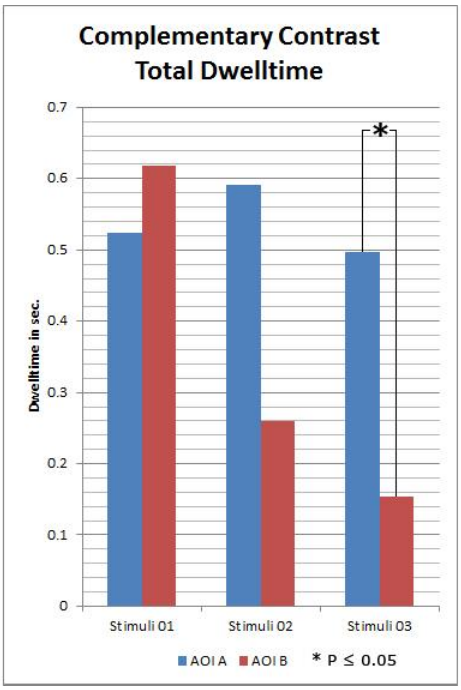


Figure 6-33 Complementary contrast total dwell-time data.

In 2 out of 3 instances (decision making, average and total dwell-times) the primary color beats out the secondary color, a rather surprising result

as the first experiment reported opposite results for the same contrast. However, only the results of the third stimulus were of significance.

6.7.3 Saturation Contrast

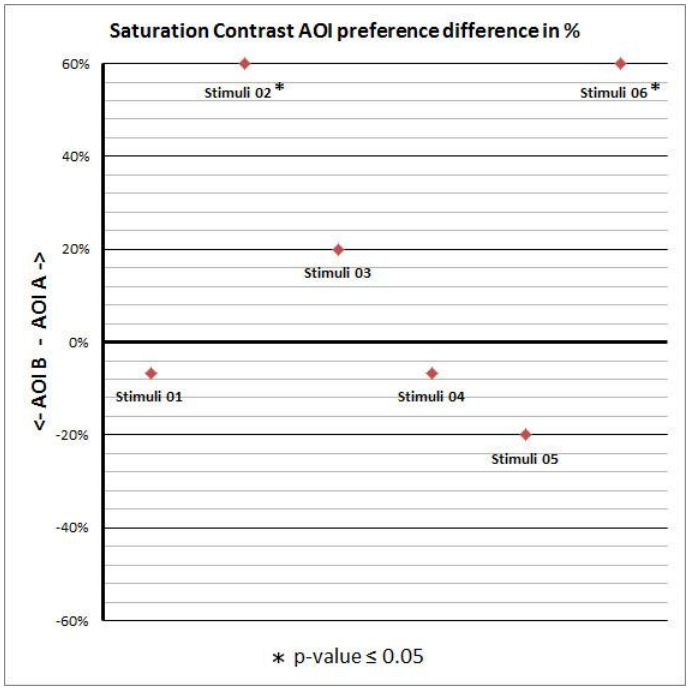


Figure 6-34 Saturation contrast choice data.

Stimulus	AOI A	AOI B
1	YMM (0% white)	YMM (50% white)
2	MCC (0% white)	MCC (20% white)
3	CYY (0% white)	CYY (60% white)
4	mcc (0% white)	mcc (30% white)
5	cmm (0% white)	cmm (50% white)
6	y (0% white)	y (20% white)

Table 6-6 Saturation contrast stimuli colors.

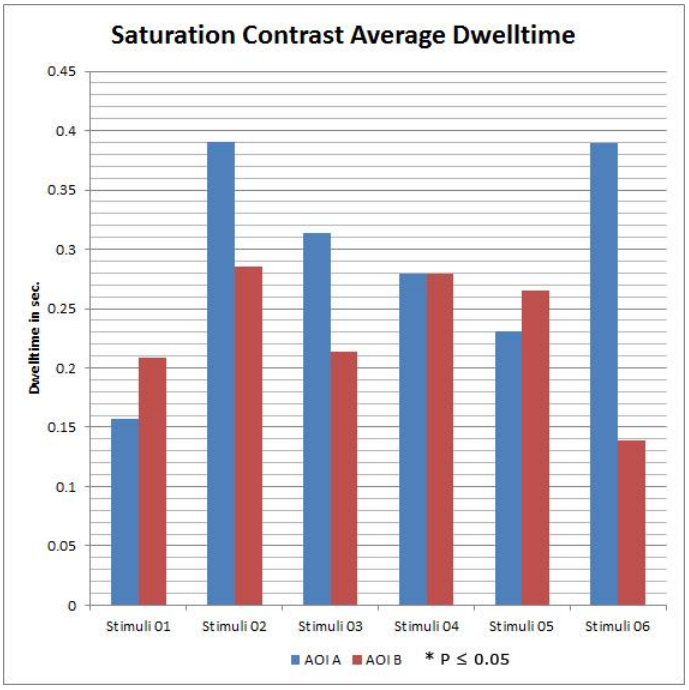


Figure 6-35 Saturation contrast average dwell-time data.

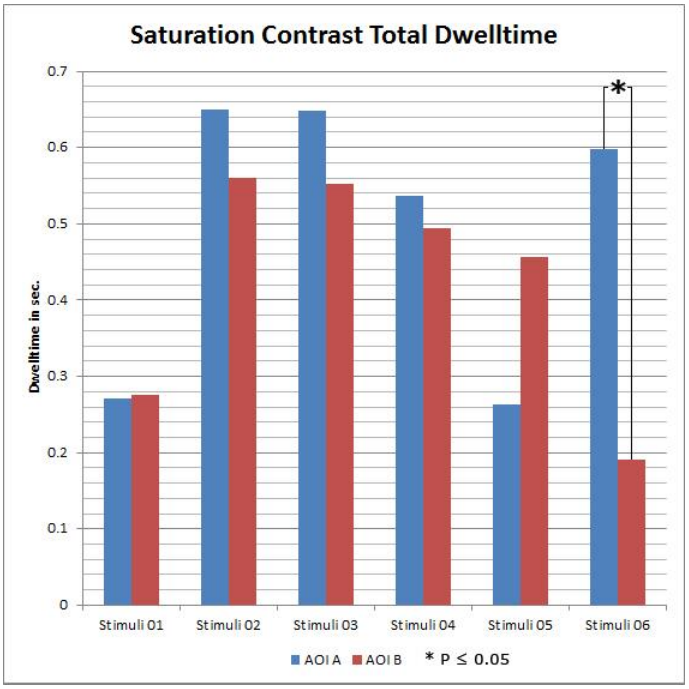


Figure 6-36 Saturation contrast total dwell-time data.

The saturation contrast gave mixed results, with the decision making being divided in-between area of interest A and area of interest B. Both the average and total dwell-times showed a very minor preference towards

the more saturated colors. The difference was especially striking in stimulus 6, which also reported a significant difference on the total dwell-time.

6.7.4 Light and Dark Contrast

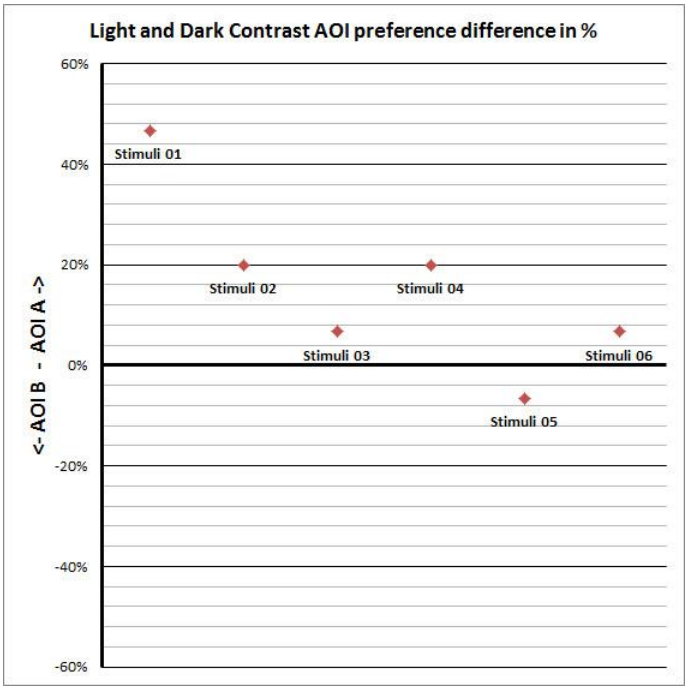


Figure 6-37 Light and dark contrast choice data.

Stimulus	AOI A		AOI B	
1	Y	(40% black)	Y	(80% black)
2	MCC	(10% white)	MCC	(20% black)
3	CYY	(20% white)	CYY	(40% black)
4	m	(20% black)	m	(70% black)
5	cy	(50% white)	cy	(60% black)
6	mcc	(60% white)	mcc	(40% black)

Table 6-7 Light and dark contrast stimuli colors.

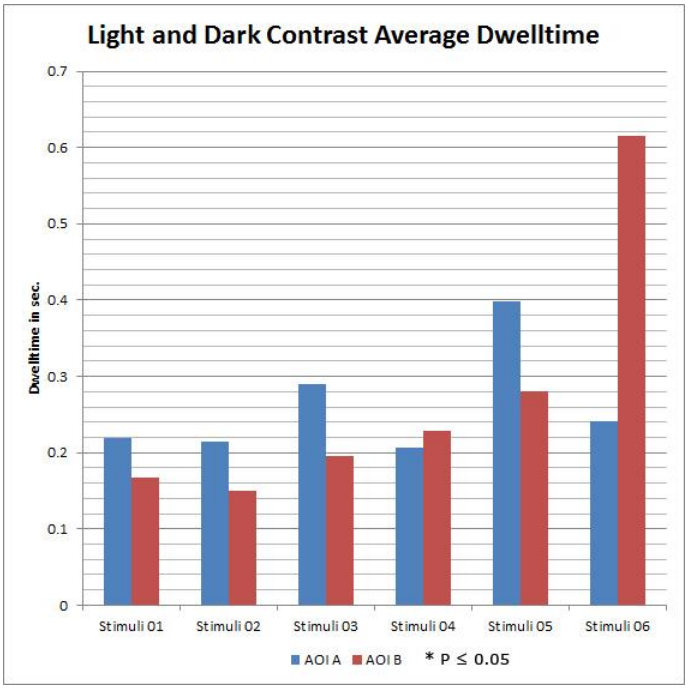


Figure 6-38 Light and dark average dwell-time data.

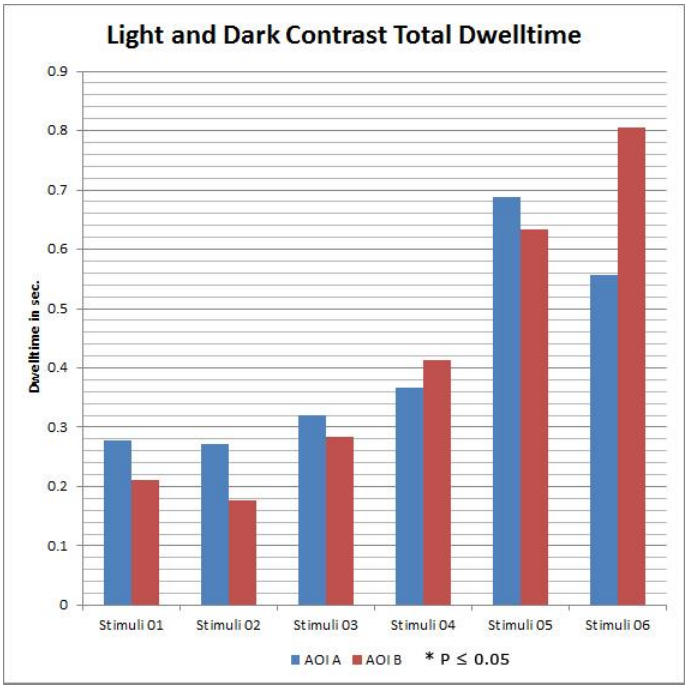


Figure 6-39 Light and dark total dwell-time data.

There was a preference towards the lighter color, even if the preference was very slight. The lighter color got the highest decision rate (5 out of 6 stimuli recorded a preference for the lighter color), though the choice data

itself turned out to be insignificant. With the average dwell times there was also a slight preference towards the lighter color. However, none of the stimuli returned significant results.

6.7.5 Contrast of Hue

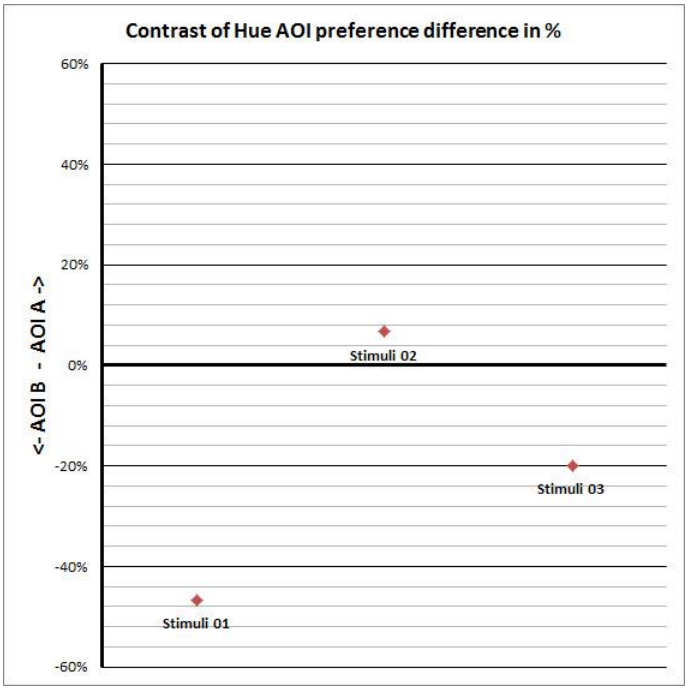


Figure 6-40 Contrast of hue choice data.

Stimulus	AOI A	AOI B
1	M	MY
2	CM	CYY
3	C	CYY

Table 6-8 Contrast of hue stimuli colors.

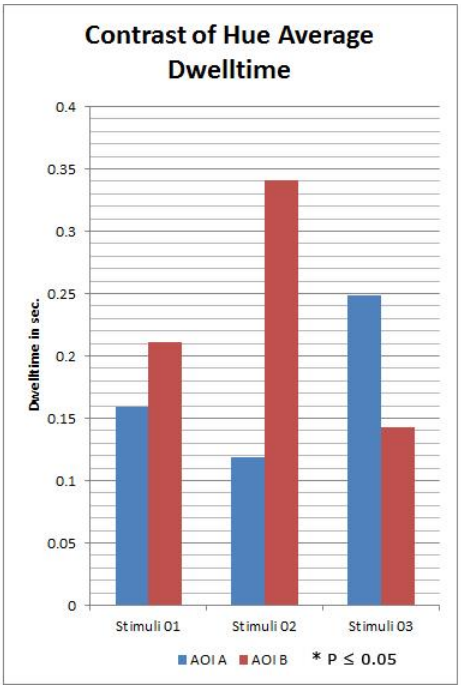


Figure 6-41 Contrast of hue average dwell-time data.

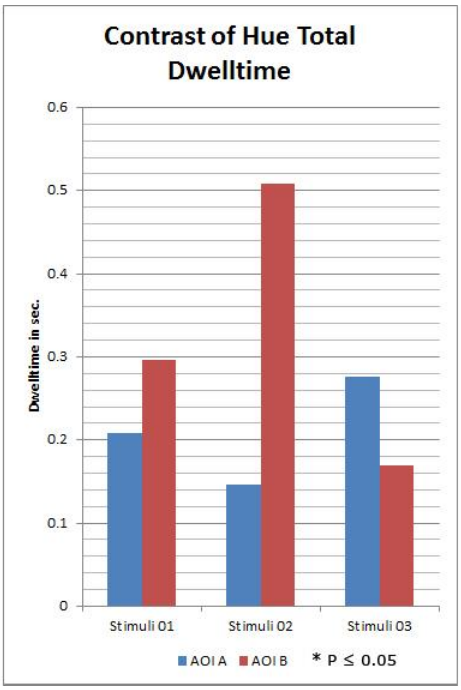


Figure 6-42 Contrast of hue total dwell-time data.

The contrast of hue performed extremely poorly, with the supposedly stronger hue losing out to the weaker hue 2 out of 3 times. The results are consistent however, even if they are not significant, with the stimuli

reporting the same findings in decision making as well as average and total dwell times.

Looking at all the results, we can conclude that color contrasts have no significant effect on viewing behavior of the participants. There's only very few stimuli that returned significant results. There are also no real differences between the significance values of either the CMYK and the RGB stimuli, meaning that what kind of color circle is being used does not have a distinct effect on participant behavior either.

6.8 Experiment 2 Luminance Analysis

6.8.1 Luminance Conditions

To analyze the effects of luminance on the participants, we had to redefine the areas of interest. Whereas with the color contrast analysis, we kept the area of interest to the two colored areas, for the luminance analysis we have defined every single area with a differing luminance value as its own area of interest.

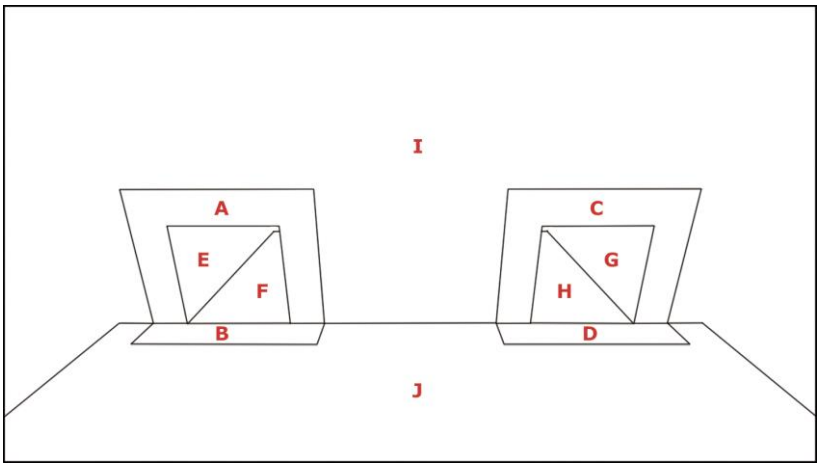


Figure 6-43 Luminance Analysis Areas of Interest redefined.

- **Luminance versus Dwell-time:** For this condition, we compared the height of the luminance values against the total and average dwell-time of each area of interest separately, in order to find out whether the height of the luminance values had any impact on viewing behavior.

- **Color versus Entrance:** For this condition, we calculated the difference of luminance values between the colored areas (AOI AB and AOI CD) and their corresponding entrance areas (AOI EF and AOI HG) in order to create a luminance contrast. Using these contrast values, we determined which colored area had the biggest contrast and compared these to the average and total dwell-times of the corresponding areas.
- **Color versus Wall:** For this condition, we calculated the difference of luminance values between the colored areas (AOI AB and AOI CD) and the wall areas (AOI I and AOI J) in order to create a luminance contrast. Using these contrast values, we determined which colored area had the biggest contrast and compared these to the average and total dwell-times of the corresponding areas.
- **Color versus Color:** For this condition, we calculated the difference of luminance values between the colored areas (AOI AB and AOI CD) to create a luminance contrast. Using these contrast values, we determined which colored area had the biggest contrast and compared these to the average and total dwell-times of the corresponding areas.

6.8.2 Luminance versus Dwell-time

As the various AOI comparisons show largely the same results, we will use one graph to illustrate the results for this condition. For reference, the other graphs can be found in [APPENDIX B].

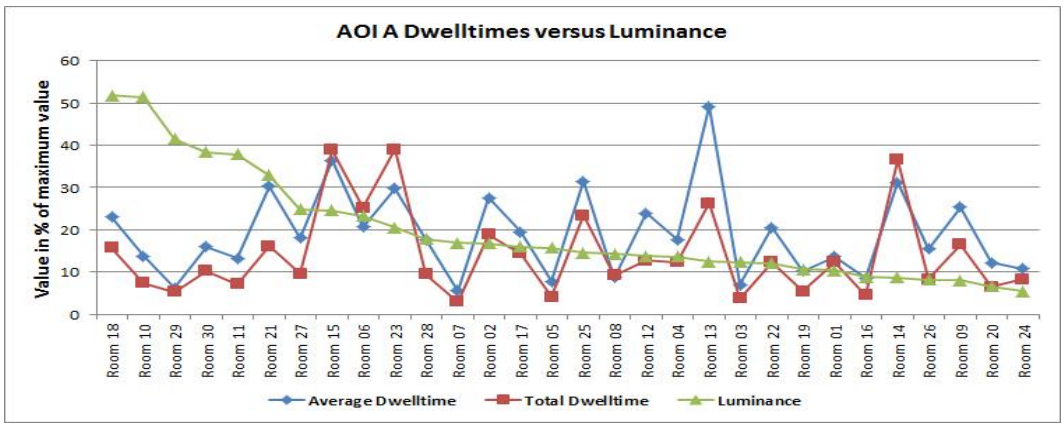
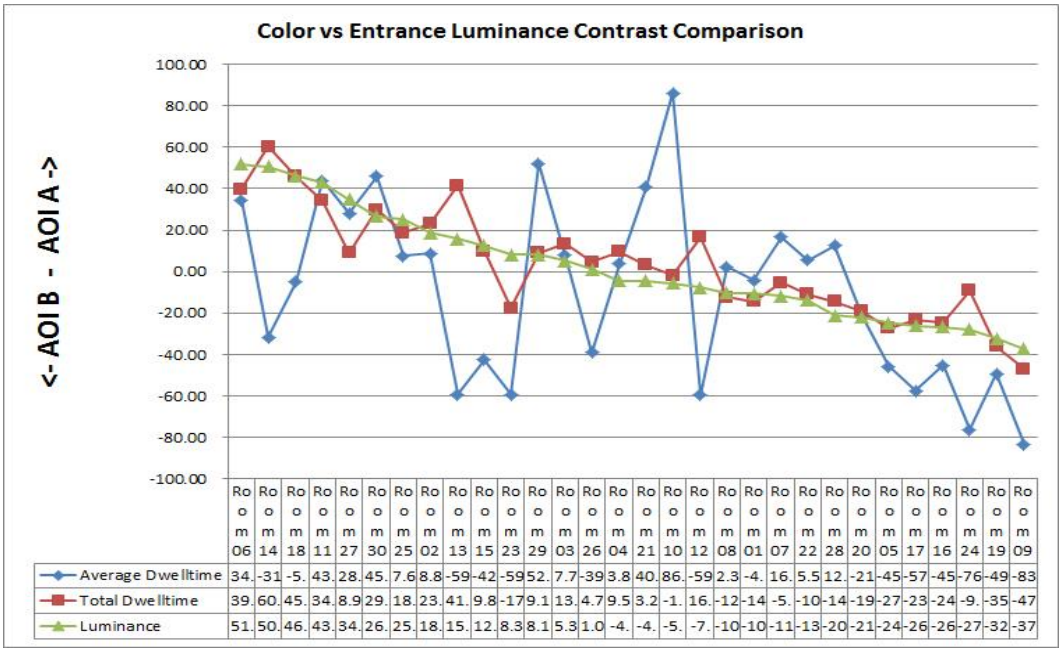


Figure 6-44 Representative dwell-times versus luminance comparison

Both the average and total dwell-times show that there is no direct correlation with the height of the luminance. As can be seen in [Figure 6-44], both high and low dwell-times occur whether or not the luminance value is high.

6.8.3 Color versus Entrance



	Room 06	Room 14	Room 18	Room 11	Room 27	Room 30	Room 25	Room 02	Room 13	Room 15	Room 23	Room 29	Room 03	Room 26	Room 04	Room 21	Room 10	Room 12	Room 08	Room 01	Room 07	Room 22	Room 28	Room 20	Room 05	Room 17	Room 16	Room 24	Room 19	Room 09
Average Dwelltime	34.	-31	-5.	43.	28.	45.	7.6	8.8	-59	-42	-59	52.	7.7	-39	3.8	40.	86.	-59	2.3	-4.	16.	5.5	12.	-21	-45	-57	-45	-76	-49	-83
Total Dwelltime	39.	60.	45.	34.	8.9	29.	18.	23.	41.	9.8	-17	9.1	13.	4.7	9.5	3.2	-1.	16.	-12	-14	-5.	-10	-14	-19	-27	-23	-24	-9.	-35	-47
Luminance	51.	50.	46.	43.	34.	26.	25.	18.	15.	12.	8.3	8.1	5.3	1.0	-4.	-4.	-5.	-7.	-10	-10	-11	-13	-20	-21	-24	-26	-26	-27	-32	-37

Figure 6-45 Color versus entrance luminance contrast comparison.

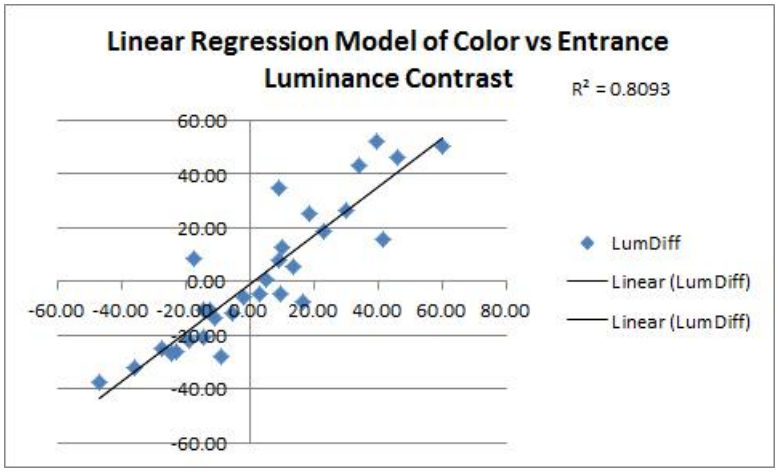


Figure 6-46 Linear Regression of total dwell-time versus luminance.

We found that, whereas the average dwell-time shows a very erratic trend, the total dwell-time in [Figure 6-45] shows a declining trend in accordance

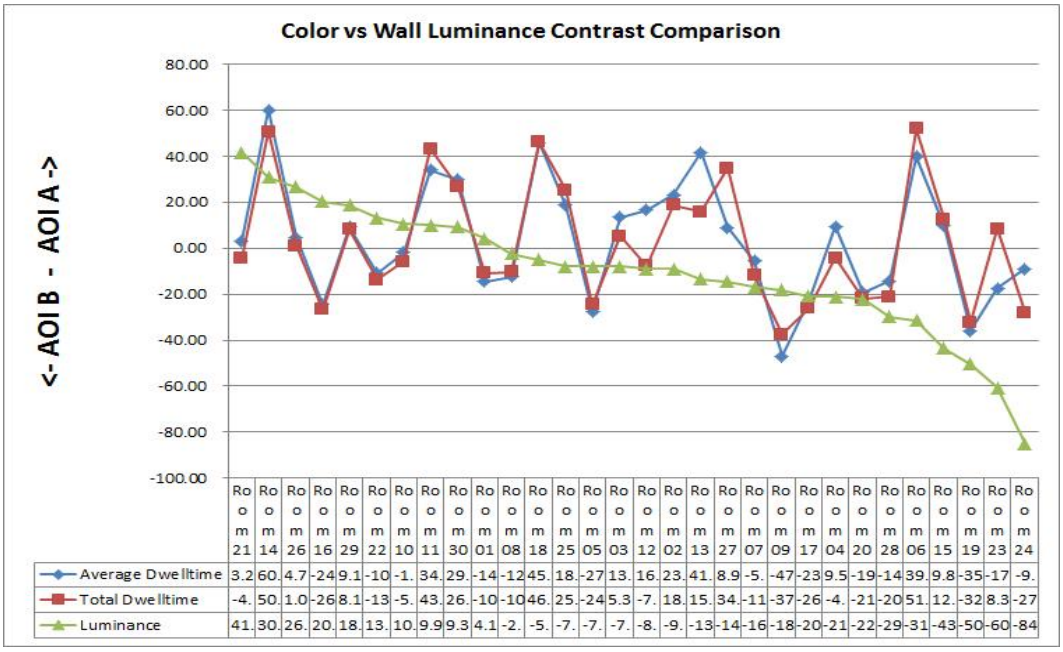
with the luminance contrast value. Furthermore, [Figure 6-46] shows that the declining trend is significant enough to be considered for further analysis.

AOI	Total dwell	% of total dwell	Surface	% of total surface
A	77.39 sec.	6.69 %	47382.50	5.16 %
B	12.26 sec.	1.06 %		
C	161.66 sec.	13.97 %	47745.50	5.20 %
D	99.76 sec.	8.62 %		
E	81.03 sec.	7.00 %	28534.50	3.11 %
F	206.22 sec.	17.82 %		
G	21.59 sec.	1.87 %	28381.50	3.09 %
H	80.29 sec.	6.94 %		
I	353.58 sec.	30.56 %	522293.00	56.92 %
J	63.16 sec.	5.46 %	242967.00	26.48 %
ALL	1156.93 sec.	100%	917604.00	100%

Table 6-9 Total Dwell-time and surface data experiment 2

[Table 6-9] shows that the areas used for this condition (AOI EF and AOI GH) received 33.64% of the total recorded total dwell-time over all stimuli. It also shows that the same areas only make up a total of 6.20% of the complete surface area of the playable area within the experimental prototype. Since these areas were designated as goals for the player, we suspect that players have given these areas a higher priority. This explains why the colored areas were taken into account in when contrasted with the entrance areas, with the entrance areas acting as the main driving force behind the participants' viewing behavior.

6.8.4 Color versus Wall

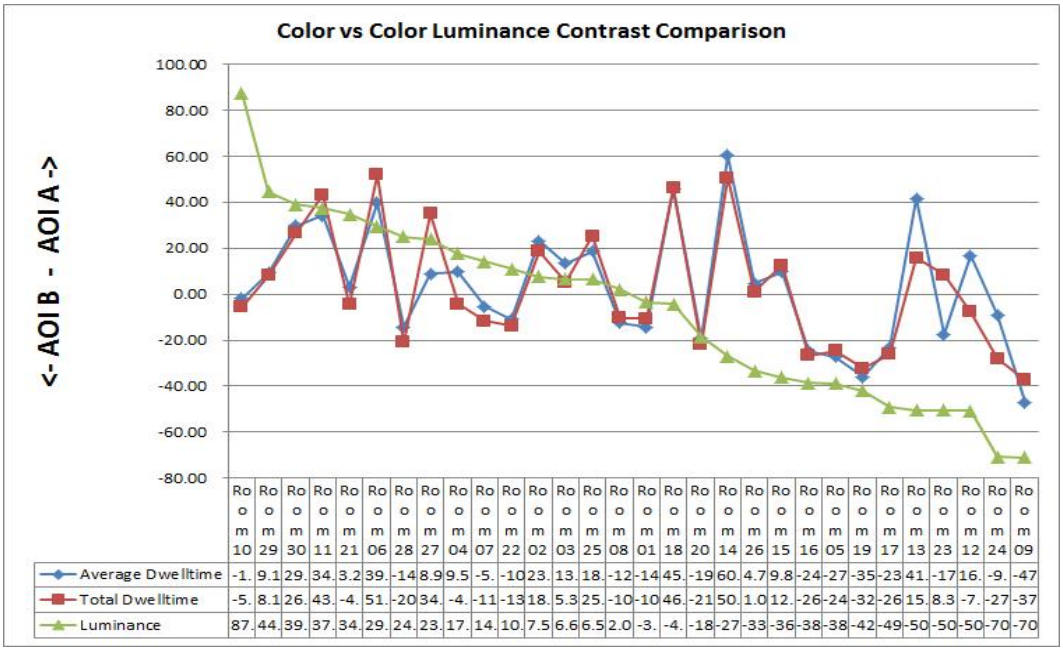


	Room 21	Room 14	Room 26	Room 16	Room 29	Room 22	Room 10	Room 11	Room 30	Room 01	Room 08	Room 18	Room 25	Room 05	Room 03	Room 12	Room 02	Room 13	Room 27	Room 07	Room 09	Room 17	Room 04	Room 20	Room 28	Room 06	Room 15	Room 19	Room 23	Room 24
Average Dwelltime	3.2	60.	4.7	-24	9.1	-10	-1.	34.	29.	-14	-12	45.	18.	-27	13.	16.	23.	41.	8.9	-5.	-47	-23	9.5	-19	-14	39.	9.8	-35	-17	-9.
Total Dwelltime	-4.	50.	1.0	-26	8.1	-13	-5.	43.	26.	-10	-10	46.	25.	-24	5.3	-7.	18.	15.	34.	-11	-37	-26	-4.	-21	-20	51.	12.	-32	8.3	-27
Luminance	41.	30.	26.	20.	18.	13.	10.	9.9	9.3	4.1	-2.	-5.	-7.	-7.	-7.	-8.	-9.	-13	-14	-16	-18	-20	-21	-22	-29	-31	-43	-50	-60	-84

Figure 6-47 Color versus wall luminance contrast comparison.

We found that for this condition, both the average and total dwell-time showed a very erratic trend. Furthermore, there is no apparent correlation between high luminance contrast differences and dwell-times as, even though the luminance contrast was largely the highest in AOI B, this wasn't reflected in either the average or total dwell-times.

6.8.5 Color versus Color



	Room 10	Room 29	Room 30	Room 11	Room 21	Room 06	Room 28	Room 27	Room 04	Room 07	Room 22	Room 02	Room 03	Room 25	Room 08	Room 01	Room 18	Room 20	Room 14	Room 26	Room 15	Room 16	Room 05	Room 19	Room 17	Room 13	Room 23	Room 12	Room 24	Room 09
Average Dwelltime	-1.	9.1	29.	34.	3.2	39.	-14	8.9	9.5	-5.	-10	23.	13.	18.	-12	-14	45.	-19	60.	4.7	9.8	-24	-27	-35	-23	41.	-17	16.	-9.	-47
Total Dwelltime	-5.	8.1	26.	43.	-4.	51.	-20	34.	-4.	-11	-13	18.	5.3	25.	-10	-10	46.	-21	50.	1.0	12.	-26	-24	-32	-26	15.	8.3	-7.	-27	-37
Luminance	87.	44.	39.	37.	34.	29.	24.	23.	17.	14.	10.	7.5	6.6	6.5	2.0	-3.	-4.	-18	-27	-33	-36	-38	-38	-42	-49	-50	-50	-50	-70	-70

Figure 6-48 Color versus color luminance contrast comparison

Like with the previous condition, the color versus color luminance contrast also showed a very erratic trend for both average and total dwell-times. There is a slight declining trend for the total dwell-time for the last 5 stimuli whose contrast was highest for AOI B, but considering the total dwell-time did not show the same results among the other stimuli we can consider this a coincidence and disregard this condition as being ineffective.

6.9Limitations Experiment 2

A possible limitation in this experiment is that the stimuli are not designed to emulate an actual game environment. Though the first experiment was designed to have an environment more closely emulating a game environment, it caused a lot of noise in the data. While this experiment was designed to eliminate that limitation, we could argue that players would behave differently if the environment was more structured like a game. Furthermore, the handedness of the participants could also be a potential limitation.

Handedness	AOI A	AOI B
Left handed	71.1%	29.8%
Right handed	48.9%	51.1%

Table 6-10 Differences of choice data between left and right handed participants.

While the right handed people were equally likely to choose either the left or the right entrance, left handed people showed a distinct preference for the left entrance. However, since there was a lack of left handed people among the participants (only 20% of all participants were left handed), we cannot conclude with certainty that handedness has an effect on what people are more likely to choose, which constitutes as a limitation to the current study.

7. CONCLUSIONS

7.1 Challenge Design

Even though challenge design is still of major importance to games, with the majority of interactive entertainment relying on it, we have little knowledge of what challenge really is. The modern definition defines it mostly by the difficulty of the challenge, but looking closer at difficulty will quickly reveal that it is far too subjective to be an effective definition. Therefore, we have proposed a new paradigm of defining challenge for video game design. Instead of looking at challenge through its difficulty, we proposed to look at challenge through how it is designed. For this reason, we state the most basic of a challenge as an obstacle the player has to overcome and analyzed major challenge design trends within game design. We found five subcategories within base challenge, or the challenge that is designed by the game creators. These are the numerical challenge, the challenge of luck, the challenge of skill, the challenge of time and the challenge of patterns.

Further building upon our categories, we analyzed ways through which proper challenge should be designed. We found a total of six challenge

design heuristics, or guidelines that will help the designer create more effective challenge design.

Lastly, we observed player habits and found that they make their own challenge. We named this meta-challenge. We found four subcategories within meta challenge, or the challenge that is designed by the players. These are the lusory challenge, the peripheral challenge, the hoarding challenge and the alacritous challenge. While meta challenge is not directly necessary for any game, taking meta challenge into account while designing a game will certainly make for a richer user experience.

We consider that these definitions will become the groundwork of challenge design research, which is necessary to become able to more effectively design what is still considered a core component of most interactive entertainment.

7.2The Game World as a Narrative Component

Games become bigger and bigger as each generation of software passes. The possibilities of the present, with games containing large sprawling 3D worlds full of life and color, as compared to those of the past, with games being severely limited by hardware and only able to convey the most necessary of information, are vastly different. Whereas in the past the major motivation to play game arguably came from gameplay, nowadays games have become very capable of immersing players, meaning that not just challenge, but the containers which are populated by challenges as well, need to be researched.

As the game industry continues to innovate, so will the worlds in which the games take place continue to grow bigger and more expressive. However, with game worlds growing to the sizes they are these days, it also becomes necessary to try and understand them. How can a game designer create a world that the player will be able to successfully immerse himself in? How can we use all of the available resources without confusing the player with too much information? In order to answer questions such as these, we first need to understand the game world itself. It is at that moment that the definitions such as those in this paper become necessary.

Using the definitions and models as defined by this paper, we will become able to understand the narrative properties of the game world itself and, as a result, we will be able to create more effective game environments. Furthermore, we will become more successful at immersing players into the game world.

7.3Visual Perception Guidance through Color Contrasts and Luminance

When looking at the game world, just analyzing the narrative properties is not enough. We also need to address the way players navigate those worlds.

In order to create an enjoyable game experience for users of varying levels of game literacy, it is necessary that methods to accommodate these players in a digital environment are researched. Game environments that confuse players will end up being frustrating to them.

Even though color remains a core component to any digital game environment, the first and the second experiment showed that the color contrasts defined by Itten, J., had no significant effects on players' viewing behavior or decision making, making those color contrasts unsuitable as a tool for guidance in digital environments. Both the CMYK and the RGB circle fared poorly, leading us to the conclusion that it doesn't matter whether the color is suited for the screen or not.

However, whereas luminance height and the majority of luminance contrasts we defined were largely ineffective, it returned significant results when we created a contrast out of the luminance values of the colored areas and the entrance areas. It was shown that participants looked longer at the areas that had a large luminance contrast, whereas the dwell-time became average as soon as the contrast value became average as well. Since the entrances areas received a lot of dwell-time, despite them taking up a relatively small part of the active surface area, we can conclude that participants gave more importance to areas that were important to them in terms of game-play. It also shows that with these important areas, participants were more likely to look at an area that had a high luminance contrast. This gives weight to the idea that

luminance contrasts, if the right conditions are met, can be used as a visual cue.

8. FUTURE WORKS

8.1Introduction

For the last decade, serious games have slowly started growing in popularity, especially in the academic field. Conversely, there is a decent body of research that has analyzed various teaching methods and educational styles noting that often, designers of games lack the necessary knowledge and experience to design a game with an educational purpose [38]. However, this ignores a large issue that is present within the field of serious games with an educational purpose. There exists a rift between the designer and the educator. The designer is not aware of how to educate its target audience, whereas the educator is not aware of how to design an effective game. Furthermore, since formal game design lore is limited, we have to contend any claims regarding effectivity of serious games. To improve on effectiveness of serious games, there is a critical need to get a better understanding of the design aspect as well.

Using the results of the visual perception research and the challenge research, the goal is to investigate the effects of visual cues on the retention rates of users of digital interactive environments, and the impact of the quantity of present elements on the average speed at which the users are able to memorize those elements. The goal is to develop a model on retention rates and speed regarding task completion in interactive environments. The initial focus will be on pattern based challenge.

8.2 Approach

8.2.1 Protocol Design

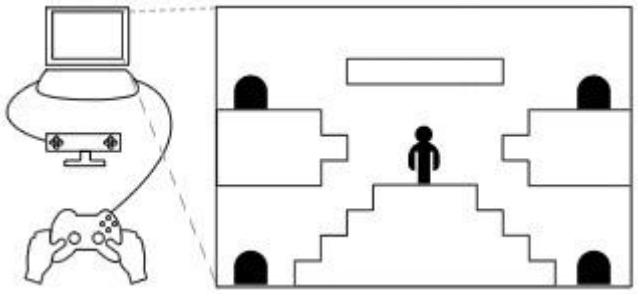


Figure 8-1 Experiment Setting for Analysis of Eye Tracking and Retention Rates of Pattern Based Task (Challenge) Design.

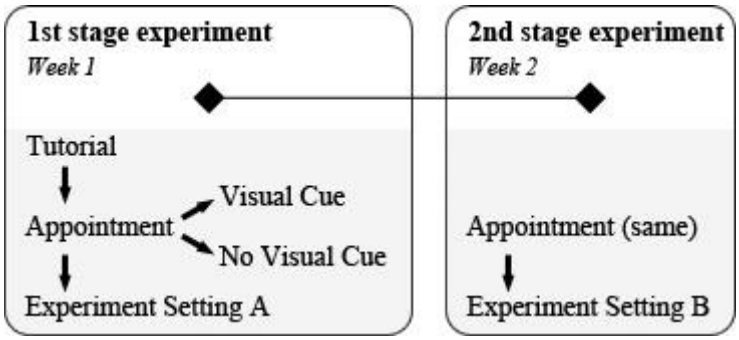


Figure 8-2 Experiment design.

An experimental prototype has been designed to contain the stimuli that will be used for this experiment. The prototype is a simplistic interactive environment, with basic interaction possible for the participant. Two sequences of stimuli have been designed. One has visual cues embedded into the environment, whereas the other has not. During the 1st stage, participants will be assigned a sequence and will be taught how to operate the prototype. The 2nd stage will put participants in the sequence they were assigned before and will assume participants still remember how to operate the prototype. The design of the stimulus starts with a hub. Depending on the difficulty of the stimulus, the participant will have access from the hub to a number of rooms that each contains a unique shape. The participant will be tasked with finding a specific shape, after which the participant returns to the main hub and is given a new task.

This process is repeated a set number of times dependent on the stimuli. After the stimulus has been completed, the participant will continue to the next stimulus and repeat the process. There are a total of 4 stimuli per sequence. The first stimulus will start with 2 shapes and with each subsequent stimulus, the present shapes will increase by 2. Tasks will be generated in random order.

8.2.2 Data Analysis

Fixations will be used to determine what quadrant the participant is looking at. Only data obtained while the participant is present within the hub will be used; this data will be used to determine whether viewing behavior is affected by retention rate. Furthermore, the participants will be timed on how long they take from the start of each task to the completion of each task. Mistakes made by the participant (choosing the wrong shape) will also be recorded. The data obtained from both sequences will be compared to see how long it takes for participants to retain the information regarding shape position and whether the use of visual cues can support the participants' rate of retention. The secondary stage of the experiment will be used primarily to determine longer term retention rates.

8.3Expected Results and Impacts

We aim to find how retention rates can positively affect users' attention spans, which eventually leads to improvement of design methodologies as well as educational methodologies. Furthermore, by analyzing the nature of task retention, we can then determine which forms of design methodologies are especially effective for didactic purposes or specific curricula.

9. ACKNOWLEDGEMENTS

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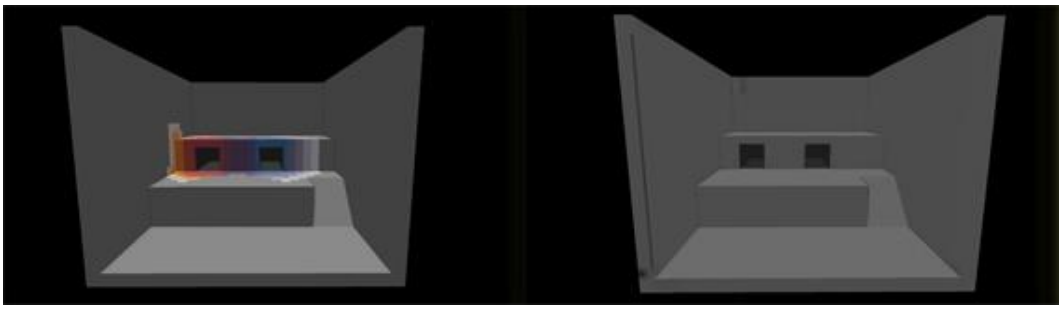
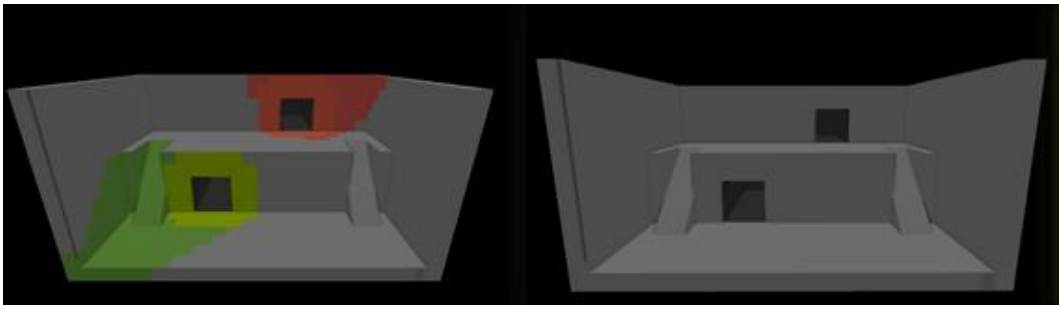
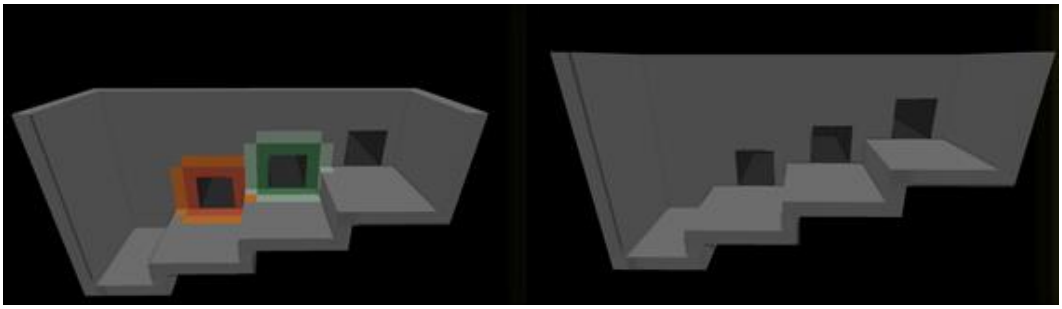
APPENDIX A COLOR EXPERIMENT 1 STIMULI



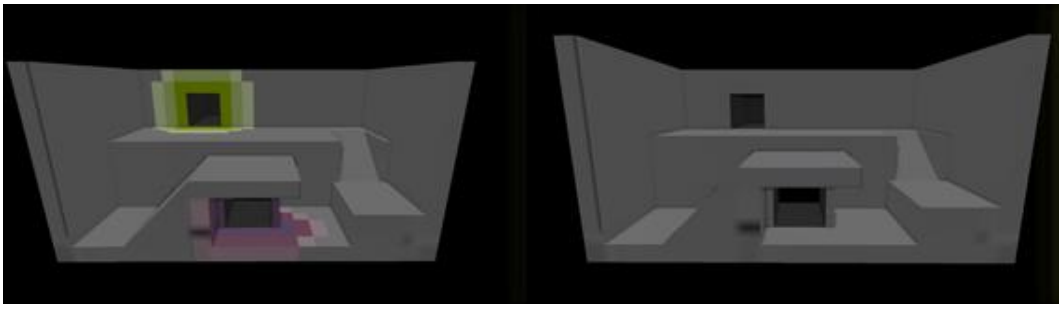
AOI A			AOI B		
Color	Black	White	Color	Black	White
M	0%	0%	C	0%	0%
YMM	0%	0%	MCC	0%	0%
MYY	0%	0%	CM	0%	0%
MYY	0%	30%	CM	0%	100%
MYY	0%	50%			
MYY	0%	100%			



AOI A			AOI B		
Color	Black	White	Color	Black	White
CY	0%	0%	M	0%	0%
CYY	0%	0%	MY	0%	0%

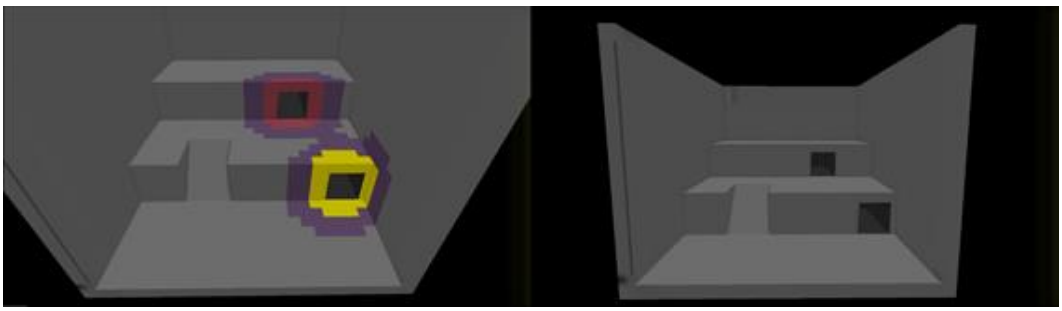


AOI A			AOI B			AOI C		
Color	Black	White	Color	Black	White	Color	Black	White
MY	0%	0%	YCC	0%	0%			
MYY	0%	0%	YCC	0%	50%			



AOI A			AOI B		
Color	Black	White	Color	Black	White
CYY	0%	0%	CM	0%	0%
CYY	0%	20%	CMM	0%	0%
CYY	0%	40%	CMM	0%	20%

Table 10-1 Experiment 1 Hot and Cold contrast stimuli



AOI A	AOI B

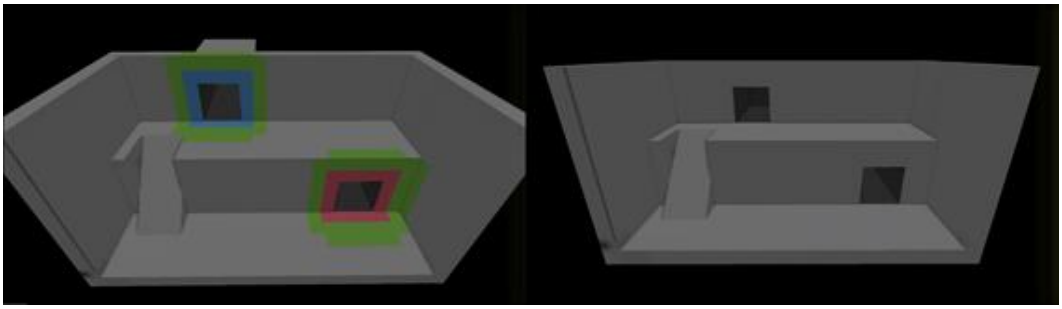
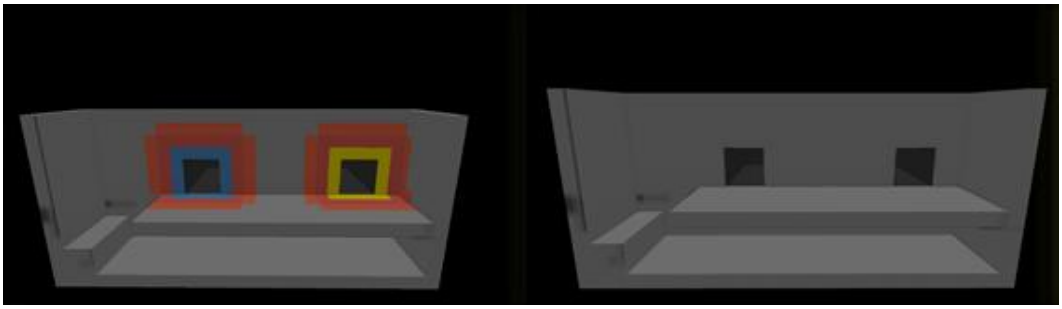
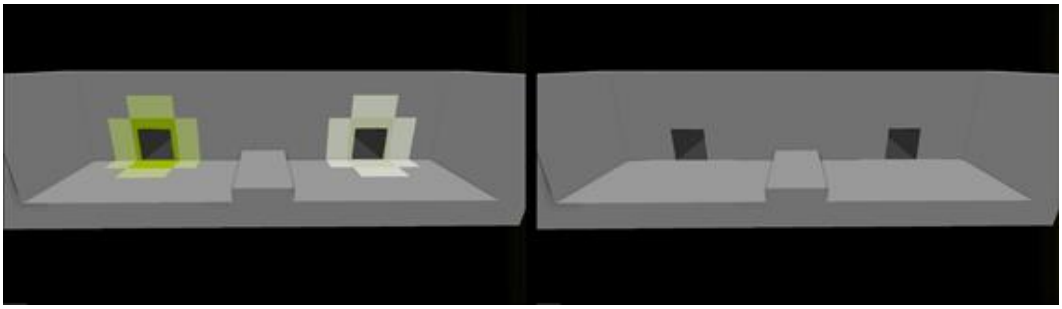
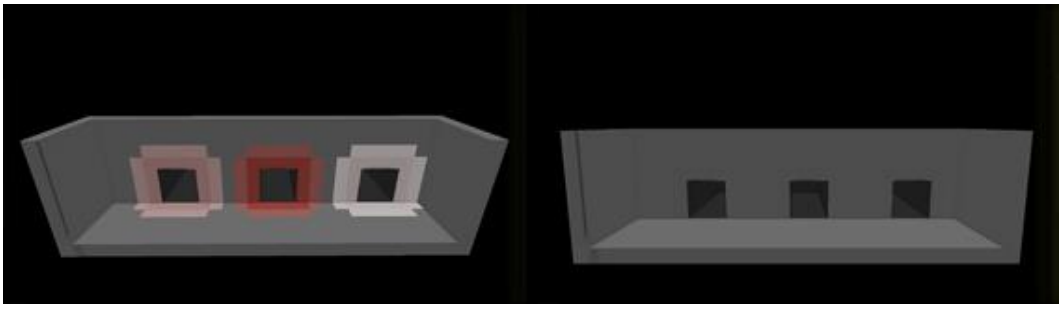
Color	Black	White	Color	Black	White
CM	0%	0%	CM	0%	0%
M	0%	0%	Y	0%	0%
					
AOI A			AOI B		
Color	Black	White	Color	Black	White
CY	0%	0%	CY	0%	0%
C	0%	0%	M	0%	0%
					
AOI A			AOI B		
Color	Black	White	Color	Black	White
MY	0%	0%	MY	0%	0%
YMM	0%	0%	YMM	0%	0%
C	0%	0%	Y	0%	0%

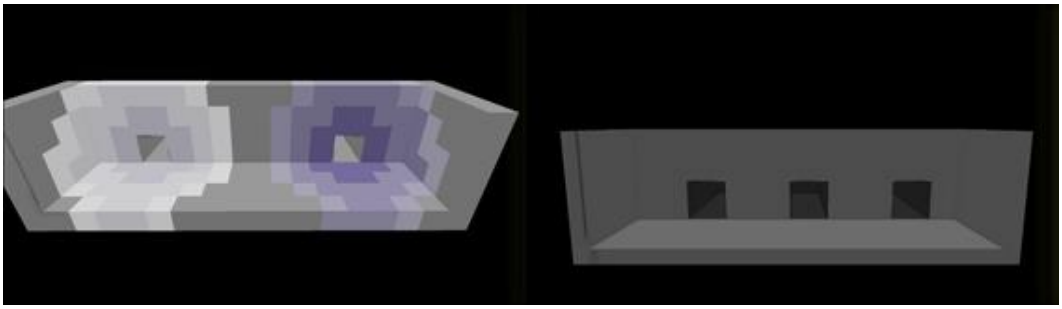
Table 10-2 Experiment 1 Complementary contrast stimuli



AOI A			AOI B		
Color	Black	White	Color	Black	White
CYY	0%	0%	CYY	0%	40%
CYY	0%	20%	CYY	0%	60%



AOI A			AOI B			AOI C		
Color	Black	White	Color	Black	White	Color	Black	White
YMM	0%	30%	YMM	0%	0%	YMM	0%	70%
YMM	0%	40%	YMM	0%	10%	YMM	0%	80%



AOI A			AOI B		
Color	Black	White	Color	Black	White
MCC	0%	40%	MCC	0%	0%
MCC	0%	60%	MCC	0%	10%

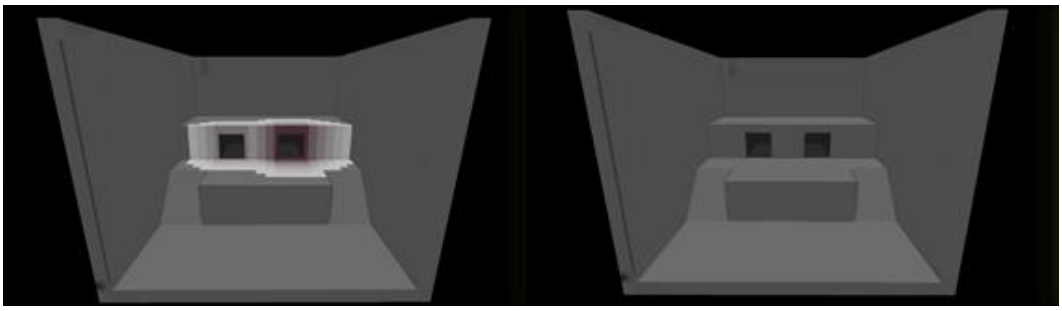
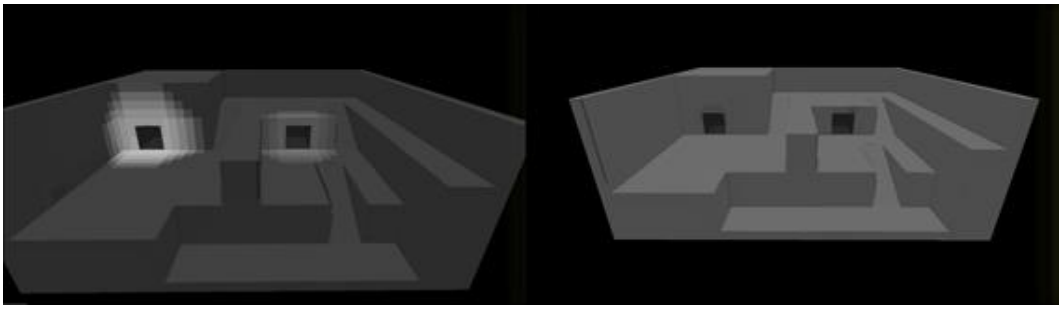
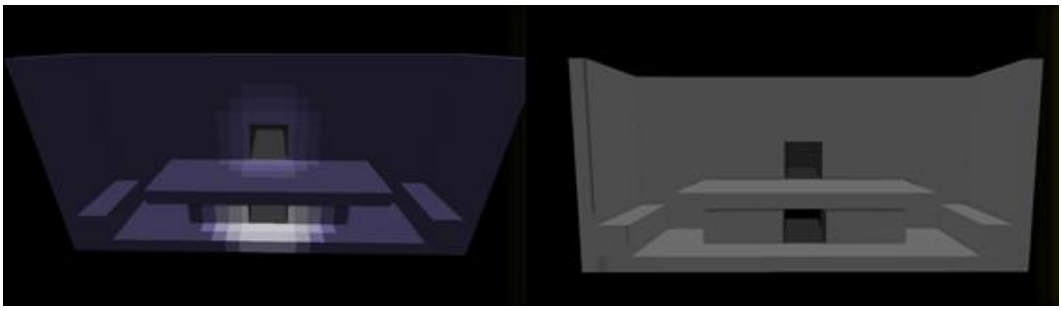
MCC	0%	80%	MCC	0%	20%
					
AOI A			AOI B		
Color	Black	White	Color	Black	White
CMM	0%	40%	CMM	0%	20%
CMM	0%	60%	CMM	0%	60%
CMM	0%	80%	CMM	0%	80%

Table 10-3 Experiment 1 Saturation contrast stimuli

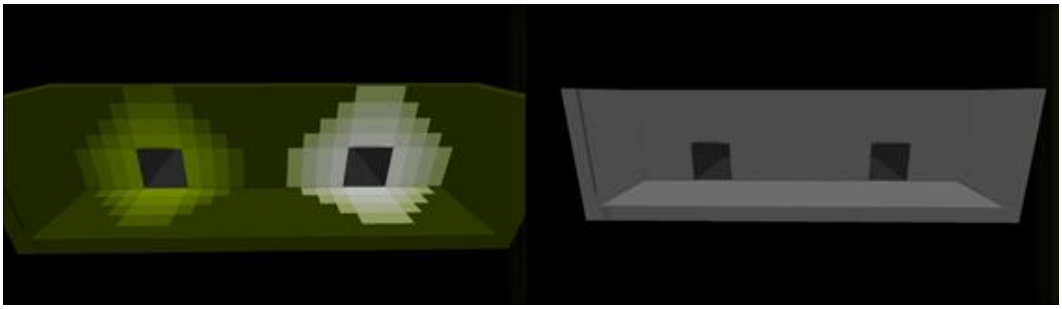


AOI A			AOI B		
Color	Black	White	Color	Black	White
WHITE	0%	0%	WHITE	85%	0%
WHITE	20%	0%	WHITE	80%	0%
WHITE	40%	0%	WHITE	75%	0%
WHITE	60%	0%	WHITE	70%	0%
WHITE	80%	0%			

AOI A			AOI B		
Color	Black	White	Color	Black	White
Y	0%	0%			
Y	20%	0%			
Y	40%	0%			
Y	60%	0%			
Y	80%	0%			

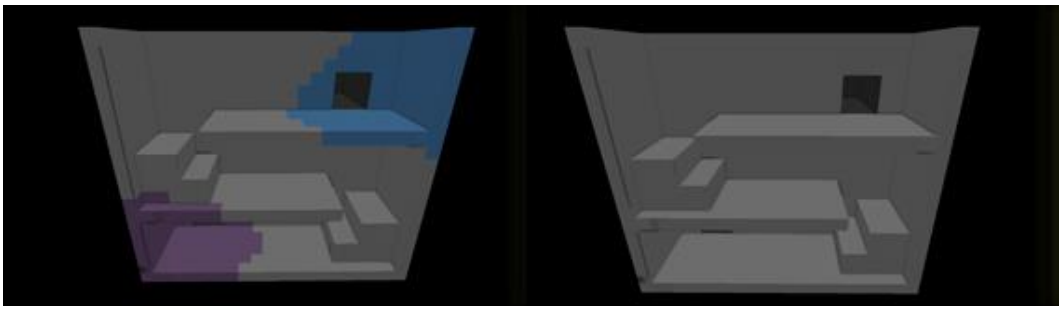


AOI A			AOI B		
Color	Black	White	Color	Black	White
MCC	0%	0%	MCC	0%	0%
MCC	20%	0%	MCC	0%	20%
MCC	40%	0%	MCC	0%	40%
			MCC	0%	60%

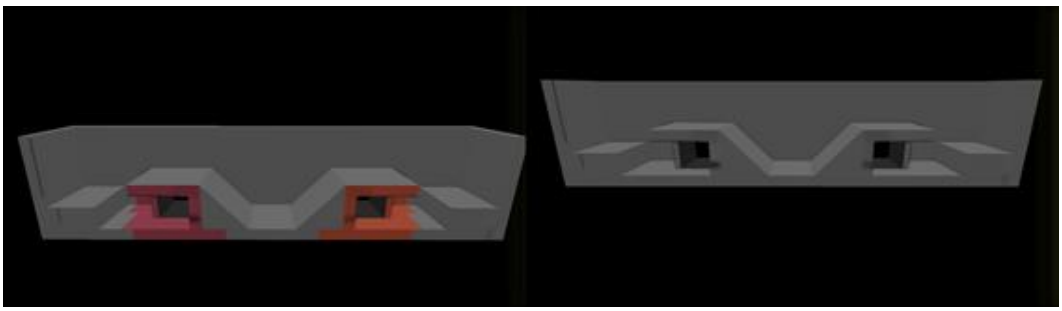


AOI A			AOI B		
Color	Black	White	Color	Black	White
CYY	0%	0%	CYY	0%	20%
CYY	20%	0%	CYY	0%	40%
CYY	40%	0%	CYY	0%	60%
CYY	60%	0%	CYY	0%	80%

Table 10-4 Experiment 1 Light and dark contrast stimuli



AOI A			AOI B		
Color	Black	White	Color	Black	White
CM	0%	0%	C	0%	0%



AOI A	AOI B

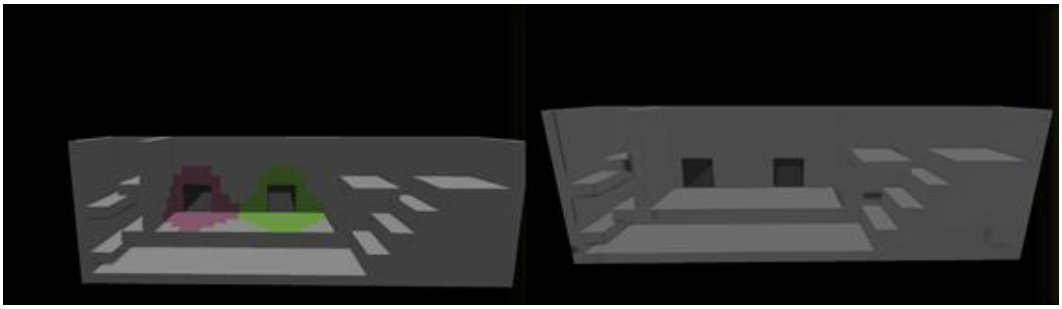
Color	Black	White	Color	Black	White
M	0%	0%	MYY	0%	0%
					
AOI A			AOI B		
Color	Black	White	Color	Black	White
CMM	0%	0%	CY	0%	0%

Table 10-5 Experiment 1 Contrast of hue stimuli

APPENDIX B LUMINANCE VERSUS DWELLTIME

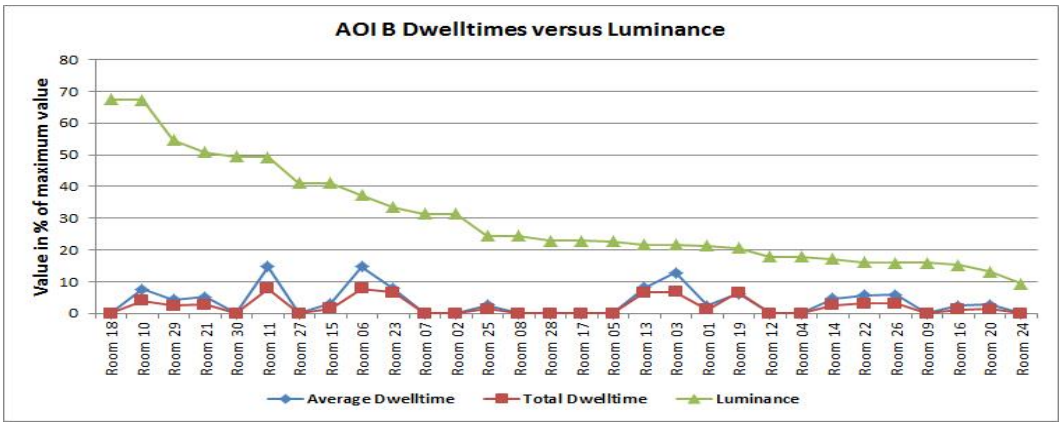


Figure 10-1 AOI B Dwell-times versus luminance

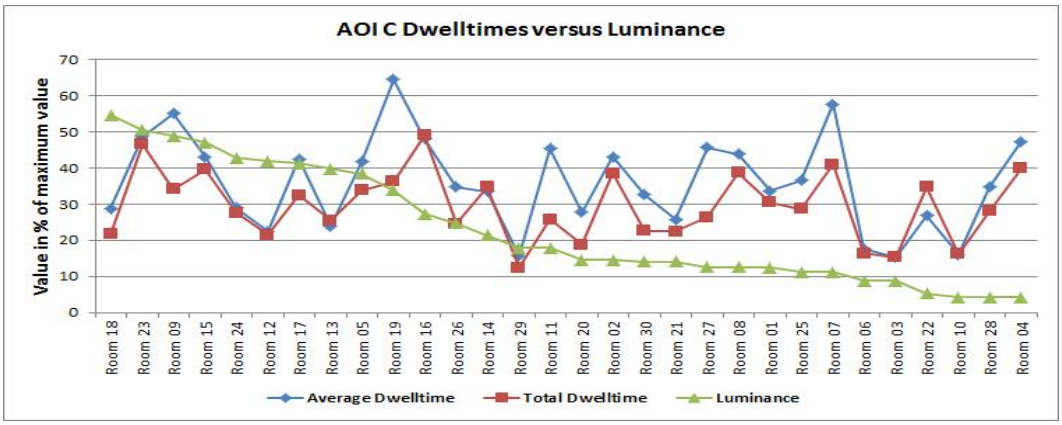


Figure 10-2 AOI C Dwell-times versus luminance

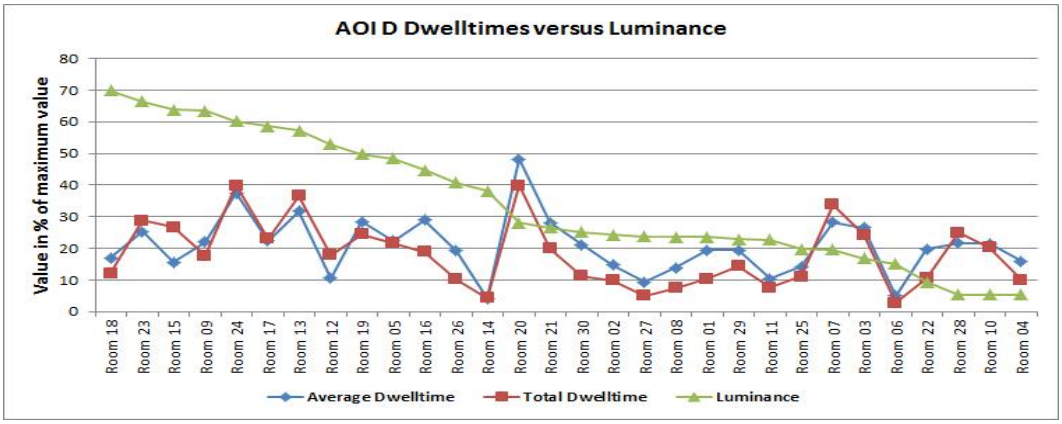


Figure 10-3 AOI D Dwell-times versus luminance

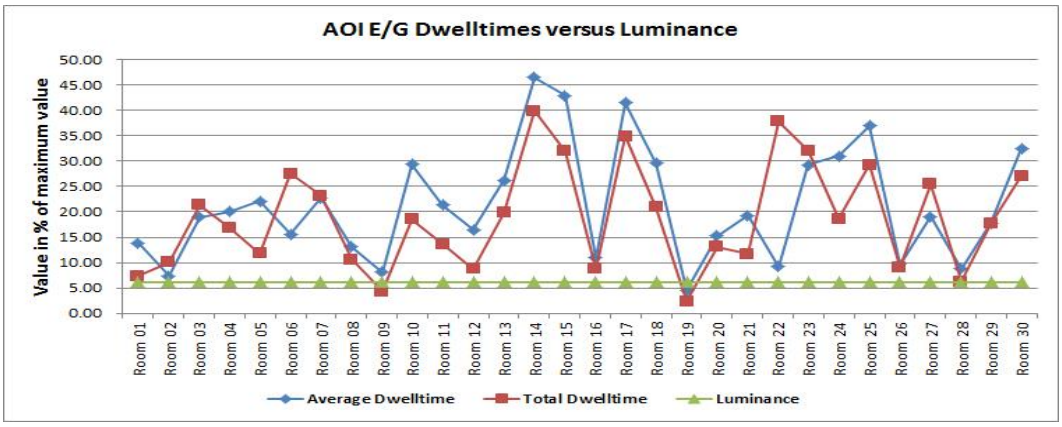


Figure 10-4 AOI E/G Dwell-times versus luminance

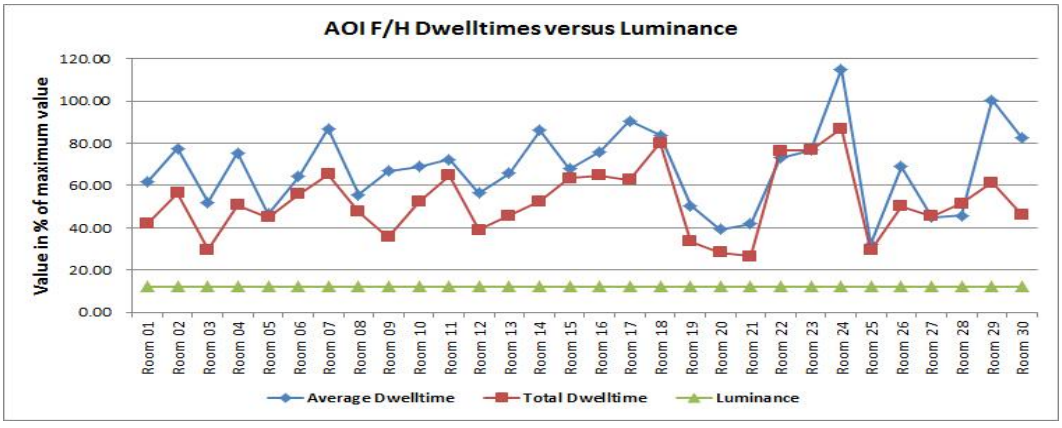


Figure 10-5 AOI F/H Dwell-times versus luminance

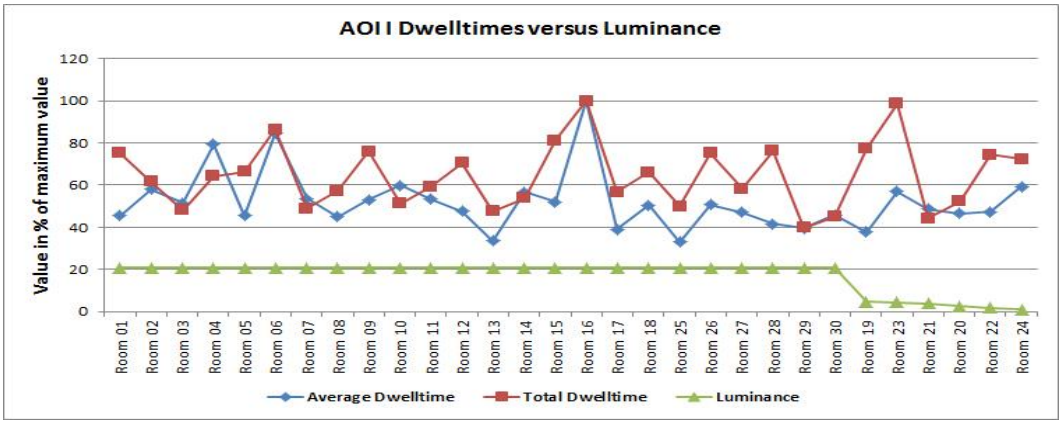


Figure 10-6 AOI I Dwell-times versus luminance

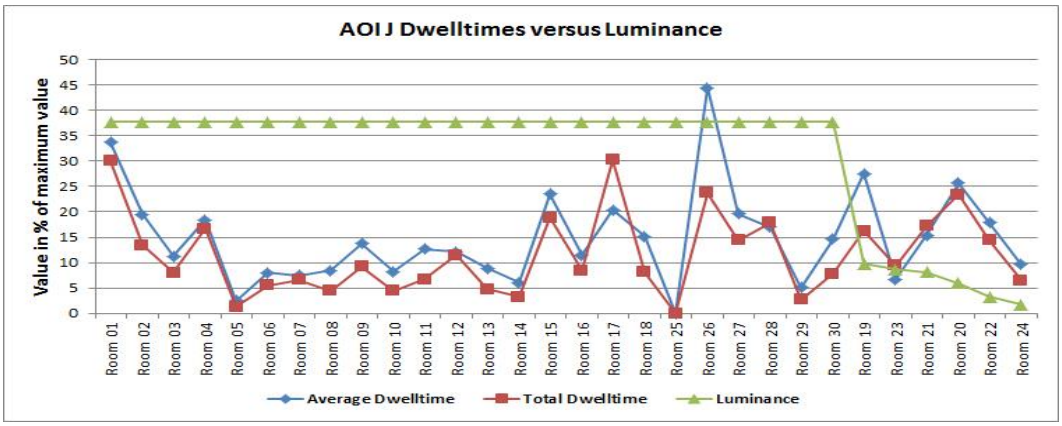


Figure 10-7 AOI J Dwell-times versus luminance

APPENDIX C CHALLENGE DESIGN SURVEYED SOFTWARE

#	Name	Numerical	Luck	Skill	Time	Pattern
1	Adventure of Link	X	X	X		
2	Alex Kidd in the Enchanted Castle	X	X	X		X
3	Alundra	X		X		X
4	Alundra 2	X		X		X
5	Angry Birds	X				X
6	Another Code					X
7	Banjo Kazooie	X		X	X	
8	Baten Kaitos	X	X			X
9	Batman Arkham Asylum	X		X	X	X
10	Battle of Olympus	X	X	X		
11	Bayou Billy	X		X		
12	Bioshock	X		X		X
13	Blue Dragon	X	X			X
14	Bravely Default	X	X	X		X
15	Breath of Fire 2	X	X			X
16	Breath of Fire 3	X	X			X
17	Breath of Fire 4	X	X			X
18	Breath of Fire Dragon Quarter	X	X		X	X
19	Castlevania Aria of Sorrow	X	X	X		X
20	Castlevania Circle of the Moon	X	X	X		X
21	Castlevania Dawn of Sorrow	X	X	X		X
22	Castlevania Harmony of Dissonance	X	X	X		X
23	Castlevania Order of Ecclesia	X	X	X		X
24	Castlevania Portrait of Ruin	X	X	X		X
25	Castlevania Symphony of the Night	X	X	X		X
26	Chrono Cross	X	X			
27	Chrono Trigger	X	X			X
28	ClockTower					X
29	Commander Keen	X				X
30	Contra 3 Alien Wars	X		X		
31	Contra 4	X		X		X
32	Crash Bandicoot	X		X		X
33	Dance Dance Revolution	X		X	X	X
34	Dark Cloud 2	X	X	X	X	
35	Darksiders	X		X		X
36	Darksiders 2	X	X	X		X

37	Day of the Tentacle					X
38	Dead Space	X		X		X
#	**Name**	**Numerical**	**Luck**	**Skill**	**Time**	**Pattern**
39	Dead Space 2	X		X		X
40	Demon Souls	X	X	X		X
41	Devil May Cry	X		X		
42	Disaster Day of Crisis	X		X	X	X
43	Dishonored	X		X		X
44	Donald Duck Maoui Mallard	X		X		X
45	Doom	X		X		X
46	Duckhunt	X		X	X	
47	Deus Ex Human Revolution	X	X	X	X	X
48	Elite Beat Agents	X			X	X
49	Fatal Frame	X		X		X
50	Fatal Frame 2	X		X		X
51	Fatal Frame 3	X		X		X
52	Fatal Frame 4	X		X		X
53	Fieldrunners	X				X
54	Final Fantasy 13	X	X			
55	Final Fantasy 4	X	X			X
56	Final Fantasy 5 Advance	X	X			X
57	Final Fantasy 6 Advance	X	X			X
58	Final Fantasy 7	X	X			X
59	Final Fantasy 8	X	X		X	X
60	Final Fantasy 9	X	X		X	X
61	Final Fantasy Adventure	X		X		
62	Final Fantasy Crystal Chronicles	X		X		
63	Folklore	X		X		X
64	Frogger	X		X	X	
65	Gargoyle's Quest	X		X		X
66	Gears of War	X		X		X
67	Geometry Wars	X		X	X	X
68	God of War	X		X		X
69	God of War 2	X		X		X
70	God of War 3	X		X		X
71	Golden Sun	X	X			X
72	Golden Sun 2 The Lost Age	X	X			X
73	Ico			X		X
74	Illusion of Time	X		X		X
75	Indiana Jones					X

76	Infamous	X		X		
77	Jak & Daxter	X		X		X
#	**Name**	**Numerical**	**Luck**	**Skill**	**Time**	**Pattern**
78	Jak 2	X		X		X
79	Jak 3	X		X		X
80	Kameo Elements of Power	X		X		X
81	Katamari Damacy	X		X	X	
82	Killer Instinct	X		X	X	
83	Kirby's Dream Land	X		X	X	
84	Klonoa Door to Phantomile	X		X		
85	Klonoa Lunatea's Veil	X		X		
86	Left 4 Dead	X		X		X
87	Legend of Dragoon	X	X	X		X
88	Legend of Legaia	X	X			X
89	Legend of Mana	X	X	X		
90	Lemmings	X			X	X
91	Little King's Story	X	X			X
92	Lost Vikings	X		X		X
93	Lufia 2 Rise of the Sinistrals	X	X	X		X
94	MadWorld	X		X	X	X
95	Magnet Loop	X			X	X
96	Mark of the Ninja	X		X		X
97	Metroid Prime 3 Corruption	X		X		X
98	Mortal Kombat	X		X	X	
99	Mortal Kombat 2	X		X	X	
100	Mortal Kombat 3	X		X	X	
101	Muramasa The Demon Blade	X		X		
102	Ni no Kuni	X	X			X
103	Okami	X		X		X
104	Osu! Tatakae! Ouendan!	X			X	X
105	Overlord	X				X
106	Pacman	X		X		
107	Persona 3	X	X		X	X
108	Persona 4	X	X		X	X
109	Phoenix Wright	X				X
110	Phoenix Wright Justice for All	X				X
111	Phoenix Wright Trials and Tribulations	X				X
112	Picross	X			X	X
113	Pitfall!!	X		X	X	
114	Plants versus Zombies	X			X	X

115	Plants versus Zombies 2	X			X	X
116	Point Blank	X		X	X	
#	**Name**	**Numerical**	**Luck**	**Skill**	**Time**	**Pattern**
117	Pokopang	X	X		X	X
118	Pong	X		X		
119	Prince of Persia	X		X	X	X
120	Prince of Persia 2008	X		X		X
121	Prince of Persia the Sands of Time	X		X		X
122	Psychonauts	X		X		X
123	Puyopop Fever	X	X		X	X
124	Ratchet & Clank	X		X		X
125	Ratchet & Clank Future a Crack in Time	X		X		X
126	Ratchet & Clank Future Tools of Destruction	X		X		X
127	Ratchet & Clank Going Commando	X		X		X
128	Rayman Raving Rabbids	X		X	X	X
129	Resident Evil Survivor	X		X		
130	Secret of Evermore	X	X			X
131	Secret of Mana	X	X			X
132	Seiken Densetsu 3	X	X			X
133	Shadow of the Colossus	X		X		
134	Shin Megami Tensei Digital Devil Saga	X	X			X
135	Shin Megami Tensei Digital Devil Saga 2	X	X		X	X
136	Shin Megami Tensei Nocturne	X	X			X
137	Silent Hill	X		X		X
138	Silent Hill 2	X		X		X
139	Skies of Arcadia	X	X			X
140	Smash TV	X		X	X	X
141	Snake			X		X
142	Sonic the Hedgehog	X		X	X	X
143	Soulblazer	X		X		X
144	Spyro	X		X		X
145	Star Ocean Second Story	X	X	X		X
146	Streetfighter 2	X		X	X	
147	Super Castlevania 4	X		X	X	X
148	Super Mario 64	X		X	X	
149	Super Mario Bros	X		X	X	X
150	Super Mario Bros 3	X		X	X	X
151	Super Mario Kart		X	X	X	
152	Super Mario Kart Double Dash		X	X	X	
153	Super Mario Land	X		X	X	X

154	Super Mario Land 2	X		X	X	X
155	Super Mario World	X	X	X	X	X
#	**Name**	**Numerical**	**Luck**	**Skill**	**Time**	**Pattern**
156	Super Mario World 2	X	X	X	X	X
157	Super Meat Boy			X	X	X
158	Super Monkey Ball	X		X	X	
159	Super Monkey Island					X
160	Super Stardust HD	X	X	X	X	X
161	Tales of Destiny	X	X	X		X
162	Tales of Eternia	X	X	X		X
163	Tales of Phantasia	X	X	X		X
164	Tales of Symphonia	X	X	X		X
165	Tales of Xillia	X	X	X		X
166	Temple Run	X		X		X
167	Temple Run 2	X		X		X
168	Terranigma	X	X	X		X
169	Tetris	X	X		X	X
170	The indredible Machine	X				X
171	The Legend of Zelda	X		X		X
172	The Legend of Zelda A Link Between Worlds	X	X	X		X
173	The Legend of Zelda A Link to the Past	X	X	X	X	X
174	The Legend of Zelda Majoras Mask	X		X	X	X
175	The Legend of Zelda Ocarina of Time	X		X	X	X
176	The Legend of Zelda Oracle of Ages	X		X		X
177	The Legend of Zelda Oracle of Seasons	X		X		X
178	The Legend of Zelda Skyward Sword	X		X		X
179	The Legend of Zelda the Minish Cap	X		X		X
180	The Puppeteer	X		X		X
181	Thousand Arms	X	X	X		X
182	Uncharted 2 Among Thieves	X		X	X	X
183	Uncharted 3 Drake's Deception	X		X	X	X
184	Uncharted Drake's Fortune	X		X		X
185	Vagrant Story	X	X			X
186	Valkyria Chronicles	X	X		X	X
187	Vectorman	X		X	X	X
188	Viewtiful Joe	X		X	X	X
189	Wario Land 3	X		X		X
190	We Love Katamari	X		X	X	
191	Wii Sports	X		X		
192	Wild Arms	X	X		X	X

193	Wild Arms 2	X	X			X
194	Wild Arms 3	X	X			X
#	**Name**	**Numerical**	**Luck**	**Skill**	**Time**	**Pattern**
195	Wild Arms 4	X	X	X		
196	Zack & Wiki: Quest for Barbaros Treasure			X		X
197	Zombies	X	X	X		
198	Zookeeper	X			X	X
	Total observed	**187**	**70**	**140**	**62**	**158**