Expected Damage of Projectile-Like Spell Effects in Games

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The authors declare that they are the sole authors of this thesis and that they have not used any sources other than those listed in the bibliography and identified as references. They further declare that they have not submitted this thesis at any other institution to obtain a degree.

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**Abstract**

**Background.** Many video games make use of particle effects to portray magic abilities known as spells. Different spells may have large variation in behaviour and colour. Aside from their different appearance, the spells often deal a different amount of damage.

**Objectives.** The aim of this paper is to evaluate how velocity, scale, and direction, as well as the colour orange and blue affect the expected damage of a projectile-like spell.

**Methods.** A perceptual experiment with a 2AFC was conducted where participants compared various spells with different values of velocity, scale, direction, and colour. The participants were asked to select the spell that they expect to deal the most damage.

**Results.** Scale had a larger impact on the expected damage of a spell than velocity. The largest and fastest spells with an added sinus based direction in the x-axis were expected to cause the most damage. However, the difference between these spells and the largest and fastest spells without the added direction was not found to be statistically significant. The orange spells were rated as more damage causing in all cases compared to the blue spells. The difference between the blue and orange preference in two of these cases were however not large enough to be statistically significant.

**Conclusions.** The results showed that the visual attributes of a particle-based spell affect its perceived damage with the scale having a greater impact than velocity and orange being the colour most often associated with higher damage. The effect of an added direction could not be evaluated due the result from the direction spells not being statistically significant.

**Keywords:** Perception, Spells, Particle Systems, Games.
I would like to thank Francisco Lopez Luro for helping and providing a framework for the perceptive experiment. I would also like to thank my supervisor Dr Veronica Sundstedt for advising me on my thesis as well as all the students that participated in the experiment.
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Chapter 1

Introduction

Magic abilities are a common occurrence in digital games. Games such as *World Of Warcraft* [1], *Skyrim* [2], and *Dark Souls* [3] all incorporate magic abilities. These abilities, often referred to as spells, can differ much from each other both in visual aspects and purpose. A fiery orb can be cast by a game character to cause destruction, or a frosty bolt surrounded by snowflakes can be used to freeze an enemy. To animate spells in digital games it is common for game developers to use particle systems [4]. With these systems, developers can design spells by assigning different values to certain attributes such as scale, velocity, direction, and colour. By changing these attributes, a vast amount of different spells can be created.

In the game *Dota 2* [5] there are over 400 spells available to the player which shows the importance of spells in games. As Dota 2 is a competitive player versus player game it is essential that players are familiar with all spells in order to be able to predict what an enemy is about to do. But the effect of 400 spells can be a lot of information to learn, especially for a new player. Different spells deal different amount of damage to game characters and structures. An evaluation of how the visual elements of a spell affect its expected damage could make it easier for game developers to understand how to design the visual aspect of spells that do low, medium, or high damage. In World of Warcraft there is two fire spells named *Fireball* and *Pyroblast* which are almost identical aside from Pyroblast causing more damage. In order to differentiate the two spells, the Pyroblast spell is significantly larger. This is an example of where more damage equals larger spell size. However, this system is not always used. Many spells remain the same size as their damage increase. Due to the lack of research in how visual behaviour of spells affect their expected damage, it

Figure 1.1: A comparison between the spells Pyroblast (left) and Fireball (right) from the game World of Warcraft. *Screenshots taken by author from https://youtu.be/IsBrm8KocyQ.*
can be hard for game developers to be consistent with their spell creation and even harder for a player to understand their behaviour.

1.1 Aim and Objectives

In this paper, we evaluate how the visual aspects of a spell created by a particle system correspond to its expected damage. Through this, a deeper understanding of the correlation of the appearance of a spell and its expected damage can be obtained which can be used when designing further spells. To gain the information required for the thesis the following steps were executed:

- Implementation of 4 unique spells in the colour orange using the Unity 3D Engine particle system [6]. These spells where then duplicated and the copies were assigned the colour blue. For each colour 1 additional spell was created with a variation in direction resulting in a total of 10 spells.
- Perceptual experiment with 19 participants, involving comparison of the spells. All spells were compared to each other and the participants were asked to mark which spells they expected to deal the most damage.
- Analysation of data obtained from the experiment.

1.2 Limitations

The behaviour of spells in games is highly varied. Some mimic projectiles and have a straight direction, others seem to defy the laws of physics and move like magic clouds or form spiralling shapes. This thesis focused on projectile-like spells when investigating the different behaviours, spells that have a clear point of origin as well as a final target point. Example of such spells are the Frost Chain spell by the character Lich in Dota 2 and the Fireball and Pyroblast from World of Warcraft mentioned in the introduction. Through this, it was easier to implement and evaluate the spells in a controllable way as well as finding comparable spells in games. Spells using known, man-made objects for the projectile such as missile heads or arrows were excluded since these objects may alter a players perception of the effect of the spell. Furthermore, this thesis focused only on the visual aspects of a spell. The spells used in the experiment did not have any sound associated with them as this could have affected the perception of the spells. The experiment was limited to two colours in order to reduce the duration of the experiment.

1.3 Research Questions

- How do velocity, scale, and direction affect the expected damage of a spell?
- How do two colours from the warm and cold colour scheme affect the expected damage of a spell?
Chapter 2

Background

This section will be used to describe some of the basic concepts mentioned in the thesis.

2.1 Unity 3D Game Engine

Unity is a 3D game engine developed by Unity Technologies [7]. It is the most popular third-party game technology software and is used by millions of people [8]. Unity was chosen as the engine for the particle implementation since it has an easy to use particle editor integrated. The particle editor allows the user to quickly design particle effects through a wide range of options. Unity is capable of simulating the particle systems in real time which further facilitates the creation of particle effects as the user can see the effects of changing variables directly in the editor.

2.2 Colour Temperature

Colour temperature is a term used to describe the perceived warmth or cold of a colour emitted from a light source. Often it is used to describe the hue of a light source lighting up a room, e.g., a light bulb in a cosy living room is emitting a "warm" light. Colour temperature is measured in Kelvin (K) on a scale of 1,000K to 10,000K. However, the actual colour of objects being heated to high temperatures does not correspond to the characteristics of colour temperature. "Warm" colours ranging at around 1000K to 3000K are actually colder than the "cool" blue colour in physics. This can be seen in a naked flame where blue flames are hotter than the red ones.

Figure 2.1: Different colour temperatures ranging from warm to cold.


2.3 Particle Systems

Particle Systems are methods used for rendering multiple 2D quadrilaterals with a texture file applied to them. These quads are often billboarded, i.e., always facing the in-game camera, making them visible from every camera angle. With particle systems, a large number of visual effects can be created. The impact on performance is also relatively small compared to other methods. For example, having a particle system simulate snow is far more efficient than rendering each snowflake as a sphere as the vertex count in the scene is greatly reduced. In order to give a particle system its desired behaviour multiple variables can be modified, some of the most common being scale, velocity, direction, lifetime, emission rate and colour.

2.4 Uses of Particle Systems

In 1983 the first paper on particle system was presented [9]. Here, the author described a method for rendering "fuzzy" objects such as clouds and fires, which was named particle systems. This system had its first major appearance in the 1982 movie *Star Trek II: The Wrath of Khan* [10], in which the particle system was used to simulate fire spreading around a planet. Since 1983, the usage of particle systems has become widespread. Usage areas includes hair animation [11], cloth drape simulation [12], and computer-generated explosions [4], which can be used in games and movies. Particles also played a role in simulating different aspects of water in the 2016 Disney movie *Moana*. A sentient water character, water splashes, walls of water, and the ocean were all simulated with the help of particles [13, 14].

2.5 How Spells Came to Games

As mentioned in the introduction, particle systems are also commonly found in digital games where they are essential in representing magic effects. But the idea that magicians and wizards can exert magic projectiles is far older than any digital video game. In the well-known fantasy book *The Return of the King* [15], first published in 1955, the author J.R.R Tolkien describes how the wizard Gandalf projects a magic white light from his hand to drive off enemies. Inspired by the fantasy works of Tolkien and others, several tabletop roleplaying games emerged [16], the most known being *Dungeons and Dragons* [17]. In this game, players could use the spells *Fire ball* and *Lightning bolt*, spells which have since then spread and adapted for use in video games. World of Warcraft is probably the digital game which has contributed the most in spreading the spell-phenomenon through its large player base and diverse spells.
2.6 Behaviour of Spells

Many spells in games are projectile based. In World of Warcraft, the playable classes Druid, Mage, and Warlock all have projectile based spells as their first available spell. These three spells, *Solar Wrath*, *Frostbolt*, and *Shadow Bolt* are spells with a clear point of origin and static size, velocity, and direction. But spells do not have to have a straight direction. Spells like *Incinerate*, also from World of Warcraft, have a side-to-side movement on its way to its target. Spells are often portrayed in different sizes, as shown by the Pyroblast/Fireball comparison in the introduction. Here, larger equals more damage dealt, much like it is expected that a large catapult would cause more damage than a slingshot. However, spells in games don’t have to follow the laws of physics. Larger spells do not have to deal more damage than smaller ones. An example where this is true is with the spells *Illusory Orb* and *Wave of Terror* by the characters *Puck* and *Vengeful Spirit* from Dota 2. Despite being roughly the same size, at max level, Illusory Orb deals more than double the damage of Wave of Terror. Spells like this make it hard for players to rely on only the size of a spell when evaluating its expected damage.

In the real world, higher velocity equals more kinetic energy which in turn result in a higher impact force. But the kinetic energy is also dependent on the object mass. By only looking at a magic spell in a game it is not possible to determine its mass. They can be estimated, but since many spells have no real-life counterpart this is not always an option. However, differences in velocities can easily be noted. In the popular multiplayer game *League of Legends* [18], the spell *Sigil of Malice* by the character *LeBlanc* travels observably faster than the spell *Flash Frost* by the character *Anivia*. Even so, they deal very similar damage. Again, this shows that a player can not rely on the velocity of a spell when evaluating its expected damage.

In a 2013 GDC presentation, Blizzard employee Julian Love talked about the importance of having the graphics and concepts of a spell match the design of it [19]. What the player sees should correlate to the expected behaviour and damage of the appearance of the spell. Love also explains that it is important that the visual area of a spell matches the area of its effect. This is a factor which results in responsive combat.

2.7 Colours in Spells

Spells can have a large variation in looks. Often, spells are meant to symbolise different schools of magic or game lore. In World of Warcraft, there are several schools of magic such as holy magic, arcane magic, and fire magic. Likewise, in Skyrim, there are 6 different types of magic, each differing from each other. Spells within a category tend to share certain looks and effects. For example, arcane spells in World of Warcraft are often portrayed with blue and purple colours. Conjuration spells in Skyrim are also often blue and purple but have very different properties than the arcane magic from World of Warcraft. In the Pokémon franchise [20], purple colour represents psychic abilities. Fire spells from these games do however share looks and
effects, as do frost spells. It seems that spells that are grounded in the real world such as fire, ice, and water spells tend to share properties and colours in games whereas more abstract spells with colours less likely to be found in nature, like purple, can have multiple meanings.

A study published in 1995 showed that colours and emotions are linked. The study showed how different colours were associated with different emotions. For example, adults associated the colour green with happiness and black with fear [21]. Therefore it is interesting that many games use colours in different ways, symbolising different things. A certain shade of green in World of Warcraft can indicate a healing spell, whereas another shade of green is present in spells by destructive, demon possessing Warlocks.

In Dota 2, developers made use of colour to signify the increased damage in the spell *Laguna Blade* for the character *Lina* compared by her other spells. All her spells are fire-related, but as Laguna Blade is the most damaging of her spells it is depicted in a light blue/white colour in contrast to her lower damaging spells which are displayed as a fiery red. A blue flame is hotter than a red one, effectively indicating that Laguna Blade is Lina’s most damaging spell.
Chapter 3

Related Work

Human visual perception has been the subject of much research. Understanding of how the human visual perception is functioning is important in many fields. In 2016 a paper was published which revealed a size-speed illusion in simulated moving objects [22]. Through an experiment the perception of speed of different sized vehicles such as cars and trains was evaluated. The study concluded that larger vehicles were perceived to have less velocity than smaller objects with the same velocity. For example, a freight train appeared to move slower than a car despite having the same speed. This size-speed illusion could affect how players perceive different sized spells in games.

A study from 2012 showed that different car models such as vans, sedans, or sports cars had different preferred colours associated to them [23]. In an experiment, participants assigned what they thought to be the most appropriate colour from a selection of 13 colours to a specific car model. Results showed that sports cars were mostly associated with the colours red and yellow and all-terrain vehicles with green. This suggests that certain colours may be better suited for certain objects than others. Likewise, there may be preferred colours for spells with a certain behaviour.

Following are two related works which used a similar experiment method as the one in this thesis, focusing on the different perception of visual stimuli:

A perceptual experiment on the boid algorithm, an algorithm used for simulating swarm-like behaviour like a school of fish or a flock of birds, was conducted by Larsson and Lundgren [24]. The goal of the experiment was to evaluate the realism of boid simulations with different values on variables such as cohesion, separation, alignment, and amount. Participants got to evaluate prerecorded video files of different boid algorithm representing school of fish. The participant then got to select which of the algorithm they perceived to be the most realistic. Results showed that the separation had the most impact on the behaviour of the school with a preferred value of approximately 60.

In 2009, a study on screen-space perceptual rendering of human skin was presented [25]. The study proposed a new skin shader which enables subsurface scattering in a screen-space diffusion approximation. A perceptual 2AFC experiment was conducted where participants were asked to evaluate two displayed images of a 3D head model using different shaders and chose the one that portrayed human skin the most.
realistically. The results from the experiments showed that the realism level of the proposed shader by the authors was equal to the realism of an earlier physically-based shader.
Chapter 4
Method

The sections below will discuss the design and procedure of the experiment.

4.1 Participants and Motivation

The data analysed in this thesis was obtained through a quantitative perceptive experiment in which volunteer students from Blekinge Tekniska Högskola were invited to participate. A total of 19 students participated with an average age of \( \sim 23.8 \). The age of the participants varied between 20 and 27.

Using a perceptual experiment provided a way to obtain data on a subjective topic which would not have been possible without users. Experiments are an efficient way of acquiring user data as experiments can be prepared and executed in a controlled way, ensuring that every participant is exposed to the same stimuli. Conducting the experiment in a laboratory environment allows for easier control of the test being executed in the conceived way. Any eventual technical malfunctions could also be handled immediately by the experiment leader. An alternative to the laboratory experiment could be to let volunteer participants perform the experiment through an online survey. This would presumably increase the number of participants as the survey would be easier accessible, leading to more data. However, there would be less control over how the test was conducted. Some participants may answer the test multiple times which would negatively affect the validity of the data.

A two-alternative forced choice method, 2AFC, was used in the experiment. Comparing two alternatives makes it easier to select an answer since there is something to reference, compared to showing only one spell at a time. The 2AFC has the added benefit of reducing ambiguous middle ground answers, which makes the results easier to interpret.

4.2 Procedure

The participants were informed about the purpose of the experiment and filled in a consent form. Secondly, the participants answered some questions regarding their age and prior gaming experience as well as naming an association with the colours orange and blue. The prior gaming experience is interesting to know since having knowledge of something can change the way it is perceived [26]. Participants
with more gaming experience may, therefore, have different expectations on spell behaviour than participants with less gaming experience. The gaming experience information was acquired through a 5 point Likert scale. Choosing an odd-numbered scale is preferred since it has a midpoint. The motivation of the colours used for the spells will be discussed further down. In a two alternative forced choice, the participants were asked to mark which of two spells they expected to cause the most damage. The spells were displayed through prerecorded video files with a length of 5 seconds. The video files were looped indefinitely allowing the participants to take their time needed. No sound was played in any of the comparisons meaning the participants answered based on the visual cues only. The order in which the spells were compared was randomised and the positioning of the video files (right or left) was altered through counterbalancing. This was done to reduce the potential bias of a stimuli being shown in a specific order since the order in which questions appear have been showed to affect answers in some cases [27]. 10 unique spells were evaluated resulting in a total of 45 comparisons. The duration of the experiment was approximately 10 minutes.

![Figure 4.1: The environment in which the experiments were conducted.](image)

### 4.3 Ethics

No significant risks were associated with the experiment. The stimuli displayed in the experiment is similar to the standard stimuli experienced by looking at a computer screen. Any user who perceived a risk to be imminent could choose not to participate without any consequences. Nevertheless, To fully ensure the ethics and safety of the experiment an ethics form was filed and sent to the Ethical Advisory Board in
4.3. Ethics

South East Sweden. Through the form, a series of ethics-related questions regarding experiment design, selection of participants and motivation of the experiment were answered. The Ethical Advisory Board approved the design of the experiment and offered some feedback on how to conduct and design the experiment in an optimal way.
4.4 Setup

The participants were seated approximately 80 cm from the display in a laboratory environment. The experiment was conducted behind closed doors to reduce external stimuli which may affect the concentration of the participant. The author of the thesis stayed in the room during the experiment to ensure that no technical malfunction occurred during the experiment. Equipment used:

- Computer: ASUS G750JX ROG Laptop
- Display: Samsung NC240 PCoIP 23.6" LCD 1920 x 1080
- Graphics card: Nvidia GeForce GTX 770M

4.5 Data

The data obtained from the experiment was output as .txt files which showed which of two compared particles was chosen as the most damaging one by the participant. When all tests were done the 19 .txt files were merged into one file. A search function then counted the number of times a certain spell was chosen as the most damaging one. This data was then analysed and presented. To determine whether the results were due to chance or if they were statistically significant a Chi-square test was used with a significance level of 0.05.

4.6 Spell Implementation

The implementation of the spells used in the experiment was done in the Unity 3D game engine. The engine provided a convenient way to create custom particle effects through its inbuilt particle editor.

4.6.1 Choosing the Values for the Experiment

To test the effects of velocity and scale on the expected damage of a spell it was decided to use two levels for each attribute as more levels would greatly increase the duration of the experiment. The different scale levels used were 1.0 and 3.0. The magnitudes used for the velocity was 2.0 and 6.0. For example, V2S3 indicates a particle system with velocity 2.0 and scale 3.0. The different scale values were assigned to the transform of the object having the particle system attached in Unity. This was done to scale all aspects of the particle system equally, which would not occur if simply changing the start size of the particle system. The different velocity levels were assigned to the velocity over lifetime channel in the particle system editor. Higher velocities led to a longer particle trail due to the individual particles travelling greater distances during the lifetime. To test the effects of direction on the expected damage of a spell one duplicate of V6S3 was created with a sine function attached to the x-axis. The sine function had the Unity delta time as input, leading to an up-and-down movement direction of the spell. Since V6S3 is compared as well the isolated effects of the direction can be evaluated. The same procedure was conducted...
with another particle system, only changing its colour. This resulted in 10 unique spells, 5 for each colour. To convey the movement of the spells without having to move the particle origin or the camera, the velocity of the particles was mapped to the U component of a striped grey background texture, making the texture move based on the velocity of the current particle system. This gave the illusion of the spells actually moving. The camera used to render the particle systems were placed at a distance of 18.25 in depth from the particle system origin. The camera was static, i.e., it did not move at any time.

### 4.6.2 Spell Colour and Texture

The colours used were one shade of orange with a hex code of FF6819, and one shade of blue with a hex code of 0C0CF0. The colours are based on a triadic colour scheme, a scheme where three colours are separated by an equal distance. Furthermore, the colours were chosen as they both are considered as different temperatures in colour temperature. Orange is considered a "warm" colour and blue a "cold" colour. The texture file used for the particle systems was a .PNG file of a smoke like shape with uneven edges, giving the spells a varied, more organic look compared to using a perfectly smooth circle.

### 4.6.3 Particle Settings

The particles had a lifetime of 1.0 seconds and an emission rate of 150 particles over time. This number was sufficient to make the separate particles form a coherent spell with no visible gaps. The particles were emitted through a hemisphere shape with a radius of 0.01 and a radial thickness of 1.0. Having a spherical shape with a minimum radius is essentially equal to emitting the particles from a single point of origin, which is required in order to get the projectile-like behaviour. Furthermore, each particle emitted was aligned to its initial direction of travel. This is an important step in order for the particle system to appear organic and "realistic". Without this, the spell would look stretched. With the use of a curve editor, the scale of an emitted particle was shrunk along its lifetime. The alpha channel of the particle colour was modified similarly, making it fade until it disappeared at the end of the lifetime. This helped in giving the spell a natural end without seeming suddenly cut off. The particles were rendered using Unity’s Anim Alpha Blended shader for particles as this shader gave a clear representation of the colours used.
Figure 4.2: To the left the scale and alpha channel of the particle system remains constant for the whole duration, in the middle, it is reduced along the lifetime. To the right is the texture used for the particles.

Figure 4.3: A snippet of Unity’s Particle System Editor.
4.6. Spell Implementation

Figure 4.4: A Screenshot of the experiment window.

Which particle effect would cause more damage? Use left and right arrow keys

Figure 4.5: The two shades of colours used for the particle system spells.
Chapter 5

Results

From the 19 participants a total of 855 comparisons were evaluated. The results have been divided into the following different sections.

5.1 Analysis of Velocity, Scale and Direction

Combining the data from both the orange and blue particle effects offers an overview of the variables affecting the expected damage outcome the most. As can be seen in figure 5.1, the spell with velocity 6.0 and scale 3.0 in combination with the sinus based movement direction (V6S3DIR) was expected to deal most damage. On a close second place is V6S3. We see that the addition of the varied direction adds to the expected damage outcome. Scale has a larger effect on the expected damage than velocity. Changing from V2S1 to V2S3, in other words increasing the scale, resulted in a higher expected damage by $\sim 435.9\%$. Changing from V2S1 to V6S1, i.e. increasing the velocity, lead to a $\sim 305.1\%$ increase. V6S3 was chosen as the most damaging spell in $\sim 29.7\%$ of the times compared to V6S1 with $\sim 13.9\%$, which further support that scale has more impact on the expected damage than velocity. However, the difference between V6S3 and V6S3DIR was not large enough to be statistically significant. The effect of the direction on the expected damage can therefore not be properly evaluated.

Table 5.1: The p-values obtained from Chi-square tests in the pairwise comparisons.

<table>
<thead>
<tr>
<th></th>
<th>V2S1/V6S1 p= 0.00</th>
<th>V2S1/V2S3 p= 0.00</th>
<th>V2S1/V6S3 p= 0.00</th>
<th>V2S1/V6S3DIR p= 0.00</th>
<th>V6S1/V2S3 p= 0.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>V6S1/V6S1 p= 0.00</td>
<td>V6S1/V6S3DIR p= 0.00</td>
<td>V2S1/V6S3 p= 0.00</td>
<td>V2S3/V6S3 p= 0.00</td>
<td>V2S3/V6S3DIR p= 0.00</td>
<td>V6S3/V6S3DIR p= 0.41</td>
</tr>
</tbody>
</table>

Table 5.2: Expected damage distribution of all spells.

<table>
<thead>
<tr>
<th></th>
<th>V2S1</th>
<th>V6S1</th>
<th>V2S3</th>
<th>V6S3</th>
<th>V6S3DIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of times selected of 855</td>
<td>39</td>
<td>119</td>
<td>170</td>
<td>254</td>
<td>273</td>
</tr>
<tr>
<td>Chosen as most damaging in (%)</td>
<td>$\sim 4.6%$</td>
<td>$\sim 13.9%$</td>
<td>$\sim 19.9%$</td>
<td>$\sim 29.7%$</td>
<td>$\sim 31.9%$</td>
</tr>
</tbody>
</table>
Chapter 5. Results

Figure 5.1: The combined preference of the particle effects from the two colours. The green circles show statistically significant pairs. The red circle shows that the difference between V6S3 and V6S3DIR is not statistically significant.

5.2 Analysis of Orange vs Blue

The results from the experiment showed that the orange colour lead to a higher damage expectation in all cases. Spells with the orange colour where chosen as the most damaging one in 492 of 855 cases (~57.5%) and spells with the blue colour 363 times, a difference of 129. The greatest difference between the damage expectancy in the two colours was found in V2S1 with a percentage difference of ~97.4%. The smallest difference was found in V6S3 where the difference in percentage was ~18.9%. However, a Chi-square test showed that the preference of colours were non statistically significant for V6S1 and V6S3 which had p-values of 0.119 and 0.132.

Table 5.3: Comparison of data from the orange and blue spells.

<table>
<thead>
<tr>
<th></th>
<th>V2S1</th>
<th>V6S1</th>
<th>V2S3</th>
<th>V6S3</th>
<th>V6S3DIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange Selected</td>
<td>29</td>
<td>68</td>
<td>102</td>
<td>139</td>
<td>154</td>
</tr>
<tr>
<td>Blue Selected</td>
<td>10</td>
<td>51</td>
<td>68</td>
<td>115</td>
<td>119</td>
</tr>
<tr>
<td>Higher Damage Expectancy In:</td>
<td>Orange</td>
<td>Orange</td>
<td>Orange</td>
<td>Orange</td>
<td>Orange</td>
</tr>
<tr>
<td>P-value</td>
<td>~0.002</td>
<td>~0.119</td>
<td>~0.009</td>
<td>~0.132</td>
<td>~0.034</td>
</tr>
</tbody>
</table>
5.3 Analysis of Colour Association

The results showed a total of 24 unique colour associations, 12 for each colour. *Fire* was the most common association found in the orange colour. Two participants associated orange with *heat* and the rest of the associations for orange were single. In blue, *water* was the most common followed by *cold* with 2 associations. Those associating orange with fire did in 4/6 cases also associate blue with water. There was not a significant difference in how people associating orange with fire answered compared to the combined answers. The associations from one participant were discarded as it contained multiple words per association.

<table>
<thead>
<tr>
<th>Table 5.4: Orange colour associations.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ember (an)Orange Fire Power Warm Chaos Heat Active Rough Angry Hazard Damage</td>
</tr>
<tr>
<td>1 1 6 1 1 1 1 2 1 1 1 1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 5.5: Blue colour associations.</th>
</tr>
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<tbody>
<tr>
<td>Nice Soft Heavy Water Cold Harmony Lightning Intelligence Divine Team-color Healing Calm</td>
</tr>
<tr>
<td>1 1 1 6 2 1 1 1 1 1 1 1</td>
</tr>
</tbody>
</table>

Figure 5.2: Bar chart showing participants particle effect preference for the two different colours. The red circles indicate that the differences between the two colours were not large enough to be statistically significant.
5.4 Analysis of Participants Gaming Experience

The majority of the participant (9 participants), categorised themselves as having a very advanced gaming experience level. On second place were participants with an advanced gaming experience (6 participants). Sharing third place was the beginner and intermediate category, both with 2 participants each. None of the total 19 participants answered that they had no gaming experience.
The results showed that scale had a larger effect on the expected damage than velocity. Increasing the scale resulted in a higher expected damage than increasing the velocity. Contrary to what was discussed in the introduction, it seems that scale is a better indicator of damage. Even though the participants could not calculate the mass of the evaluated spells, the scale appears to be more important than the velocity. A simple explanation as to why scale is more important might be that larger spells take up a larger portion of the screen, making them have a larger effect on the player. The spell that was perceived to deal the most damage was the V6S3DIR. However, the difference between V6S3DIR and V6S3 was not found to be statistically significant. Due to this, it is hard to draw any conclusions on the isolated effect of the direction. This result is somewhat surprising as the visual difference in the V6S3DIR compared to V6S3DIR is obvious. After the experiment, two of the participants shared their thoughts on the spell with the added sinus direction. One told that the added direction made it seem stronger as it went up and down. The other told that it felt like a cosmetic addition which lowered the sense of damage. The effect of direction on spells in games may not be as established as scale and velocity. It may also be harder to find real-life references to objects travelling with an up-and-down movement direction, as the V6S3DIR, compared to the projectile-like spells with a straight direction. These factors could help explain the subjective answers on the direction.

One reason why not all spells in video games follow the larger-and-faster-means-more-damage idea may be that it reduces the creative freedom of the designer. After all, games are a creative form of storytelling. Sometimes the importance of a good looking spell that matches the player character or overall ambiance of a game is more important than having a spell following certain perceptive rules.

Orange was the colour most associated with a higher spell damage. However, in two cases, V6S1 and V6S3, the difference between blue and orange was not statistically significant. Since the most popular association of orange was fire it seems that it has a larger significance on the expected damage than water, which was the most popular association in the colour blue. The higher damage expectancy in orange may be due to fire often being portrayed as a destructive and chaotic force in media. This can be seen in the boss Ragnaros from World of Warcraft and the Balrog from the first film in the Lord of the Rings trilogy [28]. The overall association of orange were of a more vivid nature. Words like ember, power, warm, chaos, active, and haz-
ard show that orange is a colour that evoke powerful associations. The blue colour associations were less wild. Associations like nice, soft, harmony, calm, divine, and healing show that blue evokes associations opposite to the ones of the orange colour. One participant told that if the blue colour would be more lightning-like it would appear to cause more damage.

The colour blue and orange have different levels of luminance, making them appear differently bright. This was not considered when choosing the colours and it is possible that the higher luminance in orange may be a contributing factor to the higher expected damage.

15 of the 19 participants had a gaming experience of advanced or higher. The result from the experiments can therefore not be used to represent a general audience. Through their gaming experience these participants in the experiment may have learned some standard behaviour of spells that the beginner gamer have not. For game developers creating a new game for beginners gamer it would therefore be interesting to conduct the experiment with people with little to no gaming experience. This could help them better design spells for the beginner player.

6.1 Source of Errors

The framework used for the experiment randomised the positioning of the video files as well as their order. As the positioning of the video files was random it is possible that a certain stimulus was displayed on one side more than the other which could lead to some bias. A better approach would be to let the stimuli alternate each other experiment, ensuring that all stimulus is displayed on each side equal amount of times. Randomising is nevertheless better than not ever changing side of stimuli and through it, the bias has at least been reduced.
Chapter 7

Conclusions and Future Work

10 unique particle based spells implemented in the Unity Game Engine were evaluated by 19 participants in a 2AFC perceptual experiment. Through this, answers to the two research questions of this study could be obtained:

- How do velocity, scale, and direction affect the expected damage of a spell?
- How do two colours from the warm and cold colour scheme affect the expected damage of a spell?

The experiment showed that increasing scale and velocity increases the perceived damage of a spell. Increasing the scale led to a higher expected damage than increasing the velocity. The spells with an added up-and-down movement direction were the spells perceived to cause the most damage. The difference between these spells and the spells with the second highest damage perception was not large enough to be statistically significant. Therefore, the effect of the added direction could not be evaluated accurately.

The results from the experiment showed that colour has an effect on the perceived damage of a spell. The orange spells were chosen as the spell expected to deal the most damage in all cases. However, in 2 of the 5 cases the difference between the preference of orange and blue was not large enough to be statistically significant.

Future experiments could be conducted with eye tracking. In this manner, it could be evaluated what draws the attention of the human eye. Elements that attain much attention could be amplified, resulting in spells with clear visuals. Further experiments could also include more variations of speed, velocity, and direction which would result in longer test durations but more reliable results.

Another interesting test could consist of letting participants design their own particles after certain descriptions. For example, a participant could be asked to design a high-level spell with high damage, a low-level spell with medium damage or maybe high-level spell with low damage. These result may be harder to draw conclusions from as they would be highly subjective. The results would, however, be interesting, especially if recurring patterns could be found among the created spells.

Evaluating additional colours from the warm-cold colour temperature scheme could give a wider understanding on what colour range is considered high damaging versus low damaging. Additionally, using colours from other schemes would be interesting.
This thesis has focused on the visual aspect of spells. As sound is a major part of perception, it could be interesting to analyse how different sound effect affects the expected outcome and damage of a spell. What happens when you put a water sound effect over a fire like spell? Are spells with little or no sound expected to deal less damage?
References


[24] Larsson M, Lundgren S. Perception of Realistic Flocking Behaviour in the Boid Algorithm [thesis]. Blekinge Tekniska Högskola. Karlskrona; 2017. Available from: http://bth.diva-portal.org/smash/record.jsf?dswid=9262&pid=diva2%3A1154793&c=1&searchType=SIMPLE&language=en&q=perception+flocking&a=%5B%5D&aq=%5B%5B%5D%5D&aq2=%5B%5B%5D%5D&aqe=%5B%5D&noOfRows=50&sortOrder=author_sort_asc&sortOrder2=title_sort_asc&onlyFullText=false&sf=all.


Appendix A

Supplemental Information

Please fill in this form before the experiment.

1. Age: ____

2. Choose the option which matches your level of gaming experience the most.

0=No experience
1=Beginner
2=Intermediate
3=Advanced
4=Very advanced

0       1               2              3              4
○―○―○―○―○

3. What do you associate these colours with? Use one word for each colour.

Figure A.1: The questionnaire given to the participants before the experiment.