Measuring How Game Feel Is Influenced by the Player Avatar's Acceleration and Deceleration

Using a 2D Platformer to Describe Players' Perception of Controls in Videogames

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ABSTRACT

The feel of videogames is important, but not very well understood. Game feel is an integral part of game design and can be defined as the moment-to-moment sensation of control in games. It is important for game designers to understand when a game feels a certain way, since it is something that the player is constantly experiencing. Unfortunately, there is a lack of vocabulary for designers to be able to create a specific game feel intentionally. There is a need of a better understanding of why certain games feel like they do, such as which parameters can be used to make a game feeling a particular way. This paper sets out to investigate what words players use to describe the feel of games, as well as what kind of parameters yield these descriptive words. This is attempted by using a 2D platforming game in which the response of the player avatar's motion is modulated. The acceleration and deceleration of the avatar change between rounds, so that the duration of these two phases are either fast (between 1 and 240 ms) or slow (between 241 and 1500 ms). This changes the feel of the game. A questionnaire was built into the game, which was then uploaded to the Internet where it can be played directly in a web browser. The game was shared on various social media and gaming communities, and it received 274 test participants. Between each round, players were asked to describe their perceived feel of controlling the avatar, as well as rate it in categories such as how 'fluid', 'floaty' and 'twitchy' the game felt. The majority used basic words to describe the feel of the game, such as 'heavy', 'slow', 'responsive' and 'realistic'. Looking at correlations between acceleration and deceleration in regards to the pre-defined words, some patterns were found. While some participants were quite sensitive to small changes, others expressed that they couldn't feel any differences. Even though all participants agreed that the feel of games is important, there still seems to be a lack of understanding behind what game feel is. Further research is needed to investigate the influence of other factors, such as game genre, graphics, sounds, level design and player attention.

Keywords

Game design, game feel, game development, perception

1. INTRODUCTION

Game design is a difficult discipline that typically requires many years of experience to get right. An important aspect of game design is *game feel*, i.e., the sensation of control in a videogame, as described by Swink [24]. Game feel is the extension of the player's senses. It's caused by a constant feedback loop between player and system. At its core, game feel can be described as the pure enjoyment of moving a player avatar[1] around on the screen. Game feel happens from the moment players form an intention in their heads and press a button, to when they see the response on the screen (e.g., the avatar jumping). Whenever players interact with a game, they are exposed to the feel of that game. This means that the feel can make or break the player experience.

The current state of designing game feel is that of an iterative process wherein designers have to carefully consider and tweak every aspect to get the game feeling "right". This process often relies on the gut feeling of the game designers, typically combined with extensive testing. They need to constantly make tiny adjustments in order to make their games feel good [7, 15, 5, 18, 26]. There is little practical framework or vocabulary that designers can build upon.

Even though game feel is usually based on the simulation of a virtual world, it can still be related to the physical world. Every object in the physical world has properties that define their unique feel, e.g., their textures, shapes and interactive properties. While a bowling ball feels massive and heavy, a knife feels sharp, pointy and thin. When it comes to games, designers and players don't have the required vocabulary to talk about these characteristics. Players might describe a certain game feeling 'floaty', 'twitchy' or 'responsive', but there are no de facto terms that can be used to talk about a specific game feel. It is uncertain when a game goes from being 'twitchy' to 'floaty'. Game feel consists of many elements, such as graphical presentation, physical simulations, sounds, player controls, input device, camera, level design, etc.

Even though game feel might be a loose concept, there are still the notion of responsiveness. Game programmer West argued that *"the 'feel' of a game is, in large part, described in terms of how responsive it is. Very often a game will be described as 'laggy' or 'sluggish', and by contrast other games will be 'tight' or 'fast'."* [28]

To get a better understanding of how players perceive and talk about game feel, this paper sets out to investigate two questions: A) What words players use to describe the feel of a game, and B) Which parameters yield those specific

[1]Merriam-Webster defines a computer avatar as *a small picture that represents a computer user in a game, on the Internet, etc.* [11]

descriptions. This study is based on a simple 2D platforming game where players control a rolling ball with the keyboard. The acceleration and deceleration of the player's avatar change, separately, between rounds. To test the influence of changing these parameters, an experiment was conducted by uploading the game to the Internet. Participants had to play the same game four times, where each round changed the acceleration and deceleration. Between the rounds, they were asked to describe the feel of the controls in their own words, as well as rate it based on predefined terms such as how 'twitchy', 'fluid' and 'stiff' the controls felt. 274 players participated in the experiment.

This paper describes the background, setup and findings of the experiment. Section 2 describes the state of the art within the area of game feel, as well as related topics. Section 3 presents a short description of the game that was developed for this project. Section 4 describes the thoughts behind the experimental design. Section 5 provides an analysis of the collected data, and, lastly, Section 6 discusses and concludes upon this data.

2. STATE OF THE ART

Game feel is a relatively unexplored research area. The primary literature on the topic is the book *Game Feel: A Game Designer's Guide to Virtual Sensation* by Swink [24]. 'Feel' is not meant in a thematic nor emotional/physical sense. Instead it's the kinesthetic sense of manipulating a virtual object — the sensation of real-time control in a videogame. Talking to game designers, Swink found that game feel is associated with intuitive controls, physical interactions with virtual objects (and the timing and impact of these interactions), as well as aesthetic pleasure and appeal in the form of polishing effects. Having analyzed various games and their components, Swink provided the following definition of game feel: *real-time control of virtual objects in a simulated space, with interactions emphasized by polish* [24]. These elements will be discussed further in the following sections.

2.1 Reacting to Player Input

An important aspect of game feel is controlling virtual objects and how responsive these controls are. Normoyle and Jörg conducted a study to investigate the relationship between the naturalness of motion (e.g., in the form of realistic and adaptive 3D animations) versus responsiveness (the game reacts instantly to the player's input, regardless of which phase the animation is in) [14]. Developers typically need to make trade-offs between naturalness and promptness when designing and implementing player controls and animations. This can affect the player's overall sense of control, enjoyment, satisfaction and performance. To test this, Normoyle and Jörg created a 3D game with varying degrees of animation blendings. The more natural the animations blend together when moving, the less responsive the character is (e.g., the player has to wait for the virtual character to complete a "turn-around" animation). While playing, 67 participants tried the different animation types. Data was collected by logging the participants' performance in the game, as well as asking them about their experiences via a post-questionnaire. Normoyle and Jörg concluded that one should always prioritize responsiveness, since low responsiveness negatively affects players' perceived ease of use, as well as their objective performances [14].

This knowledge can be tied into the Model Human Processor [3, 24], implying that games should respond to the player's input within 240 milliseconds in order to appear instant. Swink described feedback happening within 100 milliseconds as being 'instant' and within 100-240 milliseconds as being 'sluggish'. This perception is gradual, and if there is a delay of more than 240 milliseconds, the sense of real-time control might break [24]. Also, the computer must provide feedback by displaying images at a rate greater than 10 frames per second in order to maintain the impression of motion.

How quickly a game reacts to player input is important. One way to measure this latency is provided by West. He presented ways to measure response lag and how it can be minimized, by understanding the sequence of events that occur from the time the player presses a button, to when the results appear on the screen [28, 29]. By using a high-speed camera (60 frames per second) to record both the input device (e.g., a controller) and the screen, it is possible to measure this latency [10].

West also provided a good overview of how to implement intuitive non-ambiguous controls in games, by measuring the player's input and comparing it to how the game responds [27]. An example of this is what some game designers call the "ghost jump" [25, 20]: players have reached the edge of a platform and decide to jump. However, according to the game's internal physical simulation, the players have already left the ground and are therefore not able to jump. Even though they perceived themselves to be on the ground when pressing the jump button, the game fails to meet this intention. This dissonance, between what the players perceived and what actually happened in the simulation, can have a negative effect on the game feel.

2.2 Enhancing Player Experience with Polishing Effects

Polishing effects, including what some game designers call *juiciness* [2], can be used to make a game's simulation feel more alive. Game designer Schell described juciness with the following words: *"When a system shows a lot of second-order motion that a player can easily control, and that gives the player a lot of power and rewards, we say that it is a juicy system — like a ripe peach, just a little bit of interaction with it gives you a continuous flow of delicious reward."* [21] In other words, the system should give the player continuous feedback for their actions. Game designers Jonasson, Purho and Nijman demonstrated how simple games can feel better by adding layers of effects, such as bouncing motions, screen shake, particles, sounds, impact effects and fluid camera movements, to provide as much visual and auditory flair as possible [9, 13]. Berbece followed this concept and provided similar examples with animation effects [1]. To some extent, this can be related to the 12 Basic Principles of Animation, which are techniques artists can use to make their animations come to life [8]. Based on personal experience, game designer Rogers proposed a list of related techniques that can be utilized in games, such as freezing animations for a few frames to emphasize a great impact in for example fighting games. [19].

2.3 Colour Naming

Guest and Van Laar conducted an experiment to investigate how people describe colours [6]. Their approach, as well as how they categorized colours into different categories, has served as an inspiration for how to make participants describe game feel in this project.

Among ten native English speakers, Guest and Van Laar collected three types of measurements: response times, confidence ratings and consistencies. These were later collapsed into one *nameability* feature using principal components analysis, which described a single measure of ease of naming colours. The participants were seated in front of a computer and asked to name the colours on screen. It was stressed that the chosen names should be those that the participants would use to acceptably describe that colour to another person. Additionally, it was decided to not restrict the names that were allowed: participants could use unconstrained naming ('bright red') or monolexemic naming (using root words such as 'red') as they preferred. After the experiment, a classification scheme was devised in order to assist the data analysis, by splitting names into one of eight categories, based on prior research in the area:

- Landmark basic ('red', 'green', 'blue', 'yellow')
- Other basic ('orange', 'grey')
- Other monolexemic ('peach', 'lilac')
- Basic-basic ('blue-green', 'green-yellow')
- Hue-modified basic ('sea green', 'red peach')
- Lightness-modified basic ('light green', 'mid blue')
- Lightness-modified monolexemic ('light peach', 'dark turquoise')
- Other [complex] ('bright sea green')

Guest and Van Laar found that, despite the naming being unconstrained, the participants mainly used unmodified basic terms to describe the colours (such as 'red', 'green' and 'blue'), as opposed to non-basic monolexemic names and lightness-modified basic terms. This suggests that basic terms might be enough to describe the main nuances of colours. However, Guest and Van Laar also stressed that there exists regions of the colour space that are especially hard to name.

2.4 Collecting Data via the Internet

Pedersen, Togelius and Yannakakis set out to examine the relationship between level design parameters of platform games, individual playing characteristics and player experiences [17]. Their approach to collect data via the Internet has served as an inspiration for collecting data about game feel.

They constructed a computational model of players' experiences derived from gameplay interactions in a *Super Mario Bros.*-styled game. The goal was to create a system that can automatically generate content tailored to the player experience according to the needs of the game design. A neural network model was used to map between level design parameters, player behaviour and player-reported emotions. The experiment focused on three types of data: controllable level design features (e.g., number of gaps and the spatial diversity of gaps), gameplay characteristics (e.g., number of jumps, time spent running and standing still) and the players' expressions of their experiences (e.g., comparing two levels against each other)

To obtain data, Pedersen, Togelius and Yannakakis uploaded their game as a Java applet on a website (additionally, they also provided a standalone download). Users were recruited via posts on blogs and mailing lists. A questionnaire was built into the game. Each participant played a pre-defined set of four games in pairs, where the levels differed in one or more of the four controllable level design parameters. For each completed pair of games, the players were asked to report their emotional preference in a questionnaire (see Figure 1). This method allowed them to collect data from 181 test participants. Pedersen, Togelius and Yannakakis found seven features that are significantly correlated with fun, as well as several features that can predict fun.

3. DESIGN & IMPLEMENTATION

3.1 Modulating Acceleration and Deceleration

Swink discussed different ways to modulate the player avatar's movement in the chapter *Response Metrics* [24]. Inspired by ADSR envelopes (Attack-Decay-Sustain-Release), which are often used to make electronic musical instruments mimic the sound of a mechanical instrument [16], he proposed the idea of using velocity modulation to change the game feel. Even if the input signal from the controller is discrete and binary (button is either pressed down or released), the software can modulate it into a continuous signal. By altering the attack and release phase (or, acceleration and deceleration), it is possible to create different game feel, as illustrated by Figures 2 and 3.

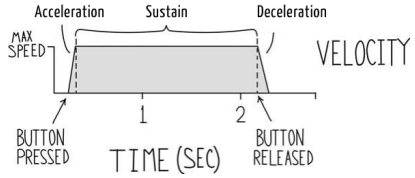

Figure 2: Short acceleration/deceleration gives a responsive, but stiff, feel. Figure inspired by Swink [24].

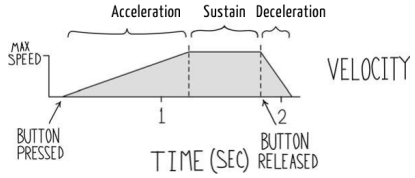

Figure 3: Long acceleration gives a loose, but fluid, feel. Figure inspired by Swink [24].

Taking inspiration from Swink, a game was developed with this concept in mind. Two parameters change between each round: how fast the ball accelerates and how fast it decelerates (when moving horizontally). Hence, the velocity of the player's avatar is modulated over time. This means that when the player presses the movement button, the ball takes a certain amount of time before it reaches its maximum velocity. The same is applied when the player releases the button: the ball gradually slows down, until it stops.

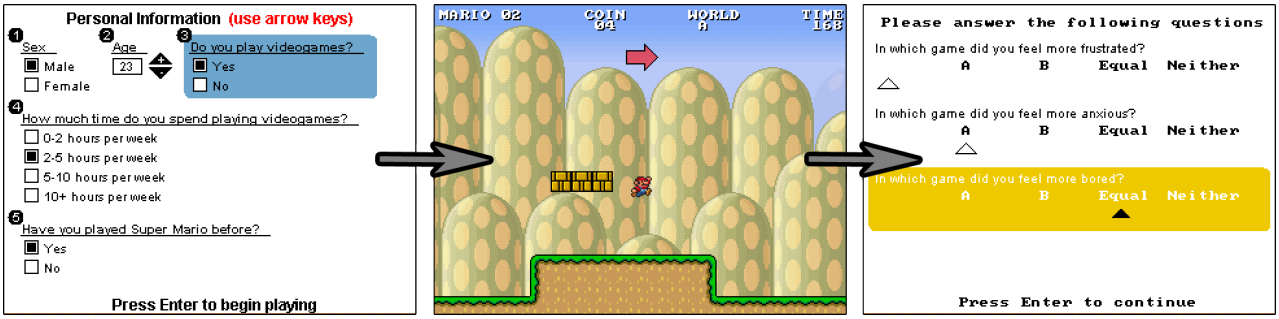

Figure 1: Using a Java web applet, Pedersen, Togelius and Yannakakis collected data about player preferences in level design, by building a questionnaire directly into the game. Figure inspired by [17].

To keep the experiment as simple as possible, only linear curves were considered for this project. Also, the decay phase was deemed unnecessary, since it wouldn't make sense for an avatar to accelerate, then decay a little, and then sustain the maximum velocity.

Two intervals were chosen, inspired by Swink's model of player perception and feedback. The first interval, *fast*, is between 1 millisecond and 240 milliseconds (staying within the limits of real-time perception). The second interval, *slow*, is from 241 milliseconds to 1500 milliseconds. For each round in the game, the player is assigned randomly-chosen time values within the two intervals. The reason for choosing random values instead of fixed values is that it isn't perfectly clear at which exact point a game goes from feeling responsive to unresponsive. Instead of choosing arbitrary fixed numbers, the system randomly assigns numbers within the two intervals. Additionally, Swink's model depicts the perception of getting discrete feedback, e.g., pressing a button turns on a light bulb after 50 milliseconds. In the case of avatar movement, there is a continuous stream of feedback while the player is holding down the movement button, since the avatar is gradually moving forward (in this game, the player controls a rolling ball). However, if the acceleration/deceleration time values are very big, the avatar will take some time before it gathers a velocity that can be perceived by the player. In other words: the values change the total amount of time it takes from when a player presses a button to when the avatar reaches its maximum velocity (or, when releasing the button, reaches a velocity of zero). The acceleration/deceleration is thus scaled depending on the time values, using Equation 1.

$$a = (v - v_0)/\Delta t \tag{1}$$

where a is the acceleration/deceleration, v is the target velocity, v_0 is the initial velocity and Δt is the time after which the target velocity is reached.

The game features other parameters, such as gravity, jump velocity and the aforementioned "ghost jump", but only the horizontal ground acceleration and deceleration changed between rounds.

The game was developed using the Unity game engine. Unity makes it easy to release for multiple platforms. With this particular project, it was chosen to make two versions (with identical content): a version that can be played in a web browser using a plugin[2] and a standalone version that can be downloaded for Windows.

Figure 4: Players control a rolling ball. Their task is to collect three stars.

The game is a traditional 2D side-scrolling platformer in which players move a small soccer ball from left to right to collect three stars (see Figure 4). The game is controlled with the arrow keys and the spacebar. Similar to *Super Mario Bros.*, there is a variable jump, meaning that holding down the button results in higher jumps.

Graphics and sound effects have been held to a minimum, since the influence of polishing effects is outside the scope of this project. Only a small trail renderer is attached to the ball. The ball also has a rolling animation that is linearly mapped to the horizontal velocity. Since the aim is to allow for players to experience the game feel as much as possible, the level has been designed to be simple and not too challenging, ensuring that most participants would complete the level without too much trouble.

To ensure that all participants had comparable experiences, the game was fixed at a 960x600 resolution, no matter if played in a browser or as a standalone program. Also, the camera is set to follow the player avatar directly; however, small deadzones for vertical and horizontal movement were implemented, meaning that the camera will only move when the player moves outside these zones (e.g., by jumping more than a few pixels).

4. EXPERIMENTAL DESIGN

4.1 Stimulus Presentation

Participants played four rounds of the game. Each round had different acceleration and deceleration values. All other

[2]Unity recently made it possible to export to the WebGL platform, but at the time of writing there are bugs and performance issues, so it was decided to use the standard web player that requires a browser plugin.

Table 1: Four different combinations.

	Acceleration	Deceleration
Stimulus 1	Fast (A)	Fast (A)
Stimulus 2	Slow (B)	Slow (B)
Stimulus 3	Fast (A)	Slow (B)
Stimulus 4	Slow (B)	Fast (A)

Table 2: Latin squares are arranged in rows and columns such that each of the stimuli conditions only occur once in each row and column. The first letter is the acceleration, the second letter is the deceleration. 'A' means fast and 'B' means slow.

	Stimulus 1	Stimulus 2	Stimulus 3	Stimulus 4
Seq. 1	AA	BB	BA	AB
Seq. 2	BB	AB	AA	BA
Seq. 3	AB	BA	BB	AA
Seq. 4	BA	AA	AB	BB

factors were held constant, e.g., the level design, sound effects and the parameters for jumping. Between rounds, participants were asked to describe how it felt to play the game. The term *game feel* was explicitly not explained, so that participants would try to describe the feel of the game from their own understanding of what game feel might be.

The experiment was designed as a repeated-measures, within-participant design [4]. This means that the participants were exposed to the stimuli (the changing acceleration and deceleration) multiple times. Additionally, each participant would see all of the available stimuli (each combination within the two categories, *fast* and *slow*), thereby acting as their own control group by comparing the different stimuli to each other.

4.1.1 *Latin Squares*

There are a total of four possible combinations, as is shown in Table 1. One of the strengths with within-participant designs is that it doesn't require as many participants as a between-participant design, since each participant will try all the conditions. However, one disadvantage is the risk of carry-over effects [22]. This might be due to fatigue (e.g., the participants become bored after having experienced the multiple conditions) or practice (e.g., the participants are better at the end than when they started).

The order in which the different stimuli are shown can affect the participant's behaviour/perception. A way to prevent this is to use a counter-balanced design. This method reduces the risks of the order influencing the results [23]. Ideally, since there are four possible conditions, there should be 4x3x2x1 different orders, i.e., 24 orders of treatment. The number of participants must also be a multiple of 24, since there should be an equal number in each group [23]. Having 24 different combinations was deemed too complex; thus, an incomplete balanced design in the form of Latin squares was used instead (see Table 2). Even though the order effects aren't eliminated completely, they become balanced.

4.2 Task

Taking inspiration from Section 2.4, a questionnaire was built into the game. Initially, participants were asked to fill in basic demographical information. Before the game started, participants were unaware of what to expect: they didn't know the range of what stimuli they would see, hence, they might be hesitant to use the extreme values on the Likert scales in the questionnaire. To counter this, participants were presented with two examples of the conditions (very *fast* and very *slow* acceleration/deceleration) in a closed environment (see Figure 5). This is called *anchoring* [4] and gives participants a common reference point of what to expect in the game. However, the game doesn't explicitly describe the two examples, i.e., stating that it's the acceleration/deceleration that change.

Figure 5: Participants were shown two examples of the extreme conditions before playing the actual game.

Afterwards, the game begins and players are asked to find and collect three stars. The purpose of the stars is to ensure that players move/jump around enough in order to experience the feel of controlling the ball. The stars have been placed in the beginning, middle and end of the level, so players have to experience the whole level each time. The level consists of traditional platforming elements, as well as obstacles in the form of a few moving enemies and spikes. Figure 6 shows an overview of the game's level.

Each time players collect three stars, the game is paused and a questionnaire is shown (see Figure 7). The questionnaire consists of three sets of questions. The first asks players to try and describe the feeling of controlling the ball on the ground and in the air, with their own words. Inspired by Section 2.3, it is stressed that the chosen word(s) should be something that the player would use to describe the feeling to a friend. As in Section 2.3, there were no restrictions on what types of words players could use (the input field's length is equivalent to approximately 66 characters, but it is possible to scroll forward/backward if a participant writes more than this). Each input field includes five randomly-chosen example words to give participants an idea of what could be used (see Table 3). Participants were asked to describe the feeling both on the ground and in air. Even though only horizontal movement is changed in the form of the acceleration and deceleration (both apply on ground and in air), there is a possibility that players perceived the game feel differently on ground and in air. Instead of trying to describe both at the same time, players were shown two

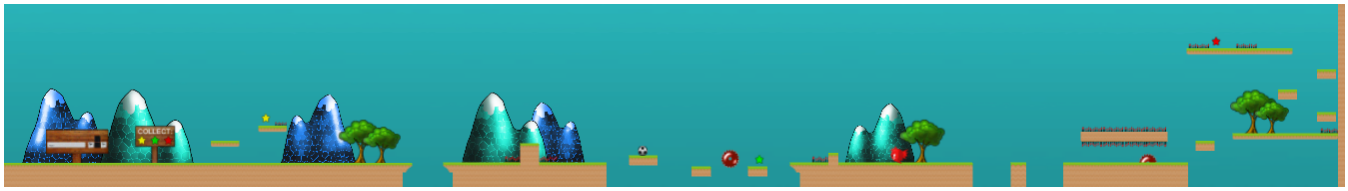

Figure 6: Participants played the same level four times.

Table 3: Participants were shown five randomly-chosen words to give them an idea of what they could write.

Fragile	Rigid	Firm	Solid	Thick
Fixed	Robust	Sore	Steadfast	Wild
Constant	Free	Hard	Tough	Restricted
Limited	Reduced	Fast	Heavy	Slow
Enjoyable	Stressful	Annoying	Realistic	Normal
Difficult	Easy	Dry	Juicy	Mechanical
Automatic	Organic	Exciting	Wet	Simple
Complicated	Direct	Inert	Unrealistic	Light

input fields.

After describing the game feel with the players' own words, a new set of questions was shown. Here, players were asked to rate the game feel on a 7-point Likert scale. Taking inspiration from Swink [24], players rated the game feeling on how *twitchy*, *fluid*, *stiff*, *floaty* and *responsive* they felt the controls were. Lastly, players were asked about how *enjoyable*, *difficult* and *frustrating* it was to control the ball, as well as *how much they liked* the control of the ball. In case players forgot how it felt to control the ball, they could always click on the *Resume Playing* button to refresh their memories before continuing with the questionnaire.

After finishing the fourth round, participants were asked to complete an online post-questionnaire. The questions here were about game feel in general: *What parameters do you think changed between each round in the ball game?* and *In your own words, how would you define the feel of games?*. Additionally, participants were asked to describe the feel of six other platforming games: *Mega Man*, *LittleBigPlanet*, *Donkey Kong*, *Super Meat Boy*, *Prince of Persia* and *Super Mario Bros.*

4.3 Participants

The game was uploaded to a server and shared on social media websites and gaming forums, such as NeoGAF, N-club, Play:Right, the Unity Community, Rock Paper Shotgun, Nintendo Life, 3D Buzz and Spiludvikling.dk, among others. The primary target group was people who already play videogames; however, others were welcome to play the game as well. The participants were oblivious to the exact purpose and methods used in the experiment; they only knew that the research topic was about game feel (however, the term was never explained), but not how this was measured.

A landing page[3] was created where participants could choose to either play the game in their browser or download a standalone build. This page also ensured that all of the participants would read the exact same description of the experiment before beginning. A $10 gift card for either Amazon or Steam was promised to one randomly-chosen participant.

Whenever a player completed a round (collecting three stars and answering the questionnaire), data was sent to an MySQL database. The data entries include demographical information (age, gender, region, previous experience with games), parameter information (acceleration and deceleration times) and player descriptions (how players described the game feel, and how they rated the game feel on the pre-defined words). Target platform, player death count, average framerate and time spent on the level were also saved.

To ensure the order in the Latin square (see Section 4.1.1), players were assigned a number between 1 and 4 when starting the game. This number corresponds to the sequences in Table 2. This was achieved by taking modulus 4 of the total amount of participants having completed the experiment and adding 1 to it. For instance, if 26 participants had played the game before entering, the next player would be assigned the sequence number $(26 \ \% \ 4) + 1 = 3$.

5. DATA ANALYSIS

The data is split into three main parts: *demographics* (before playing the game), *mid-questionnaire* (while playing the game) and *post-questionnaire* (after playing the game). The mid-questionnaire consists of two parts. In the first part, participants described the game feel in their own words. In the second part, participants rated the game feel on pre-defined words using Likert scales. The post-questionnaire is about game feel in general. The following analyzes the data from the three parts.

5.1 Demographics

As stated previously, the game was mainly shared on gaming websites. At the time of writing, 274 participants have played the game. Tables 4 and 5 show demographical data about the participants. Most of the participants rated themselves quite experienced with both playing videogames in general and playing 2D platforming games. The average death count was 5, the average framerate was 59.7 FPS and the average time spent per level was 61 seconds/level.

As stated in Section 4.1.1, ideally there should be an equal amount of participants in each of the four Latin square sequences. However, as shown in Table 6, this is not the case. This might be due to players quitting halfway, which is illustrated in Figure 8. Each time a participant collected three stars and answered the mid-questionnaire, data was logged. In total, 701 data logs were collected.

[3]The game is available here:
`http://tunnelvisiongames.com/g/GameFeel.html`

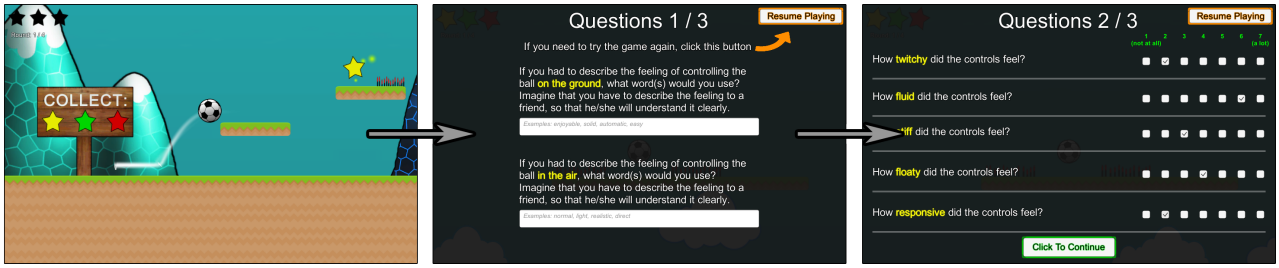

Figure 7: When the player collected three stars, the game paused and showed a questionnaire.

Table 4: Demographical data 1.

Platform	Windows Web:	Windows Exe:	Mac Web:
	55.2%	30.7%	14.1%
Gender	Male:	Female:	Other:
	93.6%	5.7%	0.7%
Age	Male:	Female:	Other:
	24.6 years	23.9 years	25 years

Table 5: Demographical data 2.

Regions		
Europe	70.6%	
Americas	26.7%	
Asia	1.9%	
Oceania	0%	
Africa	0.6%	
Other	0.2%	
Experience with...	**Videogames**	**2D platformers**
1 (none)	0%	0%
2	0%	3.1%
3	0.6%	10.1%
4	4%	14.1%
5	9.6%	23.2%
6	22.5%	16.9%
7 (a lot)	63.3%	32.6%

Table 6: The number of data entries in each of the four Latin square sequences.

	Number of data entries
Sequence 1	190
Sequence 2	179
Sequence 3	165
Sequence 4	167

Figure 9 shows the overall distribution of the combinations of acceleration/deceleration time values that participants experienced. As stated previously, the time intervals were either *fast* (1-240 ms) or *slow* (241-1500 ms). Since the lengths of the intervals are not of equal size, neither are the distribution, as shown in the figure. A way to counter this would be to divide the *slow* category into multiple smaller intervals of equal sizes, but this would also affect the number of possible sequences and Latin squares.

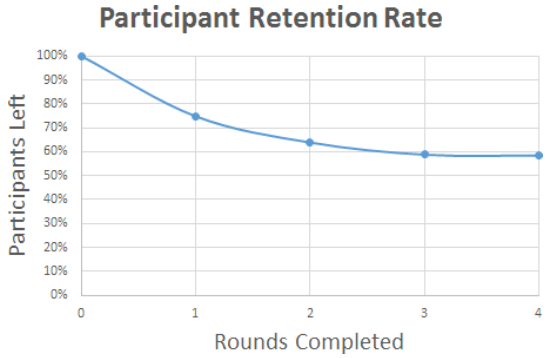

Figure 8: 274 participants started the game, but not all completed the four rounds, presumably due to fatigue or boredom.

5.2 Mid-questionnaire

Whenever players collected three stars, they were met with a set of questions (see Figure 7). In the first part, participants described the game feel in their own words, while in the second part they were asked to rate pre-defined words on a 7-point Likert scale (1 = *not at all*; 7 = *a lot*).

5.2.1 Describing Game Feel in Own Words

Table 7 shows the 30 most commonly-used words that participants used to describe the game feel (both on ground and in air). Similar to what is described in Section 2.3, the words

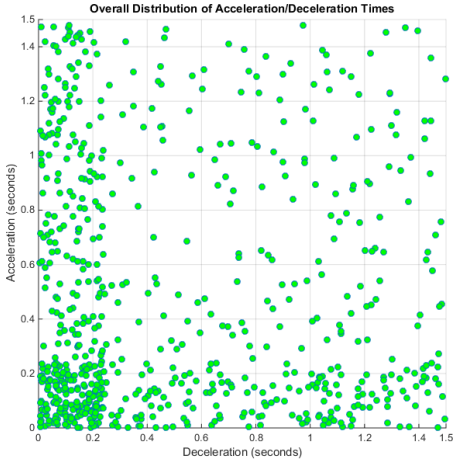

Figure 9: Scatter plot of all the different acceleration/deceleration combinations that participants experienced.

have manually, by the author, been put into one or more of the following nine categories (see Figures 10 and 11).

- Single words or multiple words?
- Basic or complex words? (basic words are root words that can stand on their own, e.g., *heavy* and *laggy*, whereas complex words consist of modifiers that somehow change the meaning of the root words, e.g., *very fast* and *a bit sluggish*)
- Did the words express anything about quality or opinion? (using words such as *fun*, *too fast*, *very annoying* and *unrealistic*)
- Did the words describe anything related to the difficulty?
- Did the words use physical properties or make comparisons to anything from the real world? (*like dragging through light mud*, using words such as *force*, *velocity* and *momentum*)
- Did the words make comparisons to other games? (*like Mario* or *like Mega Man*)
- Did the words make comparisons to previous rounds of the game? (*felt no difference from last game*)

Note that a description can include words from multiple categories. The average word count was 5.4 words for ground descriptions and 5.1 words for air descriptions.

Interestingly, there were some participants who had problems feeling any difference between the four rounds. One participant kept writing *"No difference at all"*. This participant was presented with the following four sequences [acceleration;deceleration]: **[0.03;0.07]**, **[0.3;0.78]**, **[1.0;0.2]**, **[0.1;0.4]**. Assuming that the system worked correctly, it seems odd that the participant could not feel any difference between the rounds.

Below are some selected quotes and their corresponding acceleration and deceleration values in square brackets (ascending order of acceleration values).

- Grounded, wavy, skill-based, inertia, chunky. **[0.03;0.66]**
- It's okay fast. Not with an acceleration, just one constant speed (which maybe makes it easier to control but then again more boring to look at). **[0.05;0.21]**
- Only goes where you want it to go. No physics. **[0.05;0.07]**
- Very responsive, felt "right". **[0.06;0.03]**
- Icy. **[0.07;1.16]**
- Super twitchy, ball moves right when you press keys. **[0.09;0.14]**
- Annoying, no fine control, noticeable input delay. **[0.1;0.18]**
- Very static. Actually easier once you're used to it, but less intuitive and fun. **[0.22;0.49]**
- Feels like you're rolling a big ball down a hill almost — it takes a bit of time to get going. **[0.27;1.47]**
- It feels really heavy and has a bit of after roll that adds a bit of reality feeling physics to it. **[0.3;0.52]**
- Like Super Mario (which is good). **[0.34;0.14]**
- Heavy like a bowling ball, smooth. **[0.38;0.74]**
- Unrealistic, stiff. The fact that it stops on a dime, except when you press in the opposite direction feels odd. **[0.52;0.07]**
- The ball felt really good, and I liked that it didn't stop completely when I stopped pushing the button. **[0.52;0.26]**
- BAD!!! Not like a ball at all. It is confusing. **[0.93;0.07]**
- Extremely annoying and heavy. Way too slow acceleration and reaction time in change of direction was truly painful. **[0.97;0.29]**
- Slow, annoying, snappy. **[1.0;0.03]**
- Fast, but also slippery. **[1.06;1.17]**
- It controls like a truck with square wheels. **[1.19;0.07]**
- Lots of momentum, ball takes a while to accelerate and a while to decelerate. **[1.22;1.29]**
- Very slow to start, stopped really fast. Punishing to not "give full throttle". **[1.24;0.09]**
- Mechanical, sometimes "jumps" forwards. No fine control. **[1.3;1.1]**
- Sluggish, not fun. **[1.31;0.77]**
- Heavy and unpleasant as hell. **[1.41;0.02]**
- Felt like dragging through light mud with reasonable control. **[1.41;0.12]**
- Sticks like glue. **[1.47;0.01]**

Ostensibly, there are different opinions on what feels "right". As one would expect, some of the higher values yield more frustrating results, since there is a longer delay before the participant sees the result on the screen. Some participants tried to describe the feeling using words from the physical world, such as *momentum*, *acceleration* and *friction*. Others expressed themselves whenever they felt that the controls were *too heavy* or *too unresponsive*. Some compared it to *a heavy tank moving through mud*, while others critiqued that the movement was *unrealistic* and *didn't feel like a ball at all*. Some participants were eager to express how much more *difficult* or *easier* the game was due to the controls, while others emphasized personal opinions, such as it feeling *too fast* or *not fun*.

5.2.2 Rating Game Feel with Pre-Defined Words

Using a 7-point Likert scale, participants also rated the game feel on the following pre-defined terms.

- Twitchy
- Fluid
- Stiff

Table 7: The 30 most commonly-used words to describe the feel of the ball game. Numbers in parenthesis indicate usage frequency. Common grammar words have been excluded.

heavy (165)	slow (132)	ball (122)
responsive (104)	fast (94)	like (90)
control (87)	very (83)	too (80)
easy (78)	momentum (61)	realistic (61)
sluggish (58)	floaty (58)	bit (54)
air (52)	good (51)	unrealistic (51)
feels (50)	little (45)	hard (42)
felt (40)	fluid (39)	still (38)
ground (37)	jump (37)	same (36)
speed (35)	time (34)	stop (31)

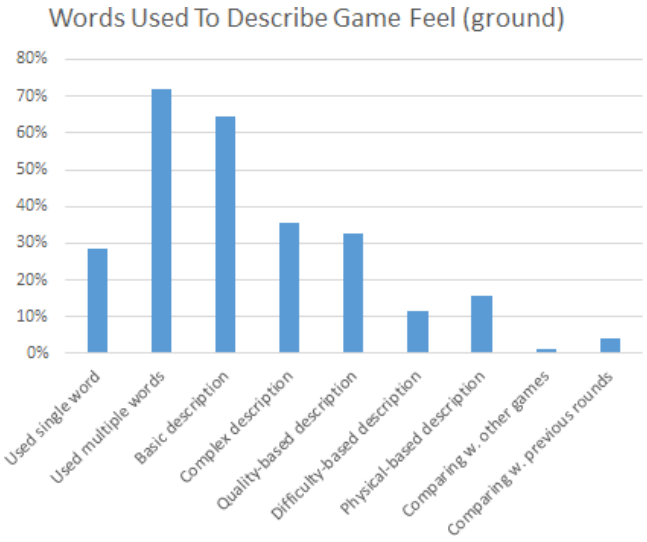

Figure 10: The different types of words participants used to describe the game feel on ground.

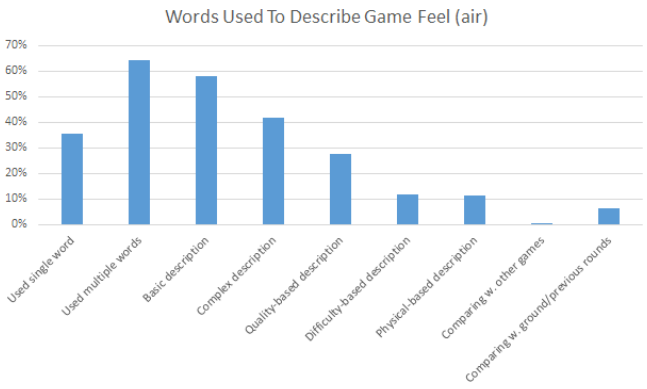

Figure 11: The different types of words participants used to describe the game feel in air.

- Floaty
- Responsive
- Enjoyable
- Difficult
- How much they liked the controls
- Frustration

5.2.3 *Looking at Acceleration & Deceleration Values Separately*

Figure 15 shows the correlation matrix. Here, it is possible to spot a few tendencies, e.g., acceleration having a negative correlation with how *twitchy*, *fluid*, *floaty* and *responsive* the game felt. Meanwhile, deceleration has a positive correlation with how *twitchy* and *floaty* the game felt. However, this way of showing the data is not accurate, since it splits the acceleration and deceleration. The participants did not experience either separately; both were always apparent when playing.

5.2.4 *Looking at Acceleration & Deceleration Values Simultaneously*

Since the distribution of the acceleration/deceleration times wasn't equal (due to the two intervals, *fast* and *slow*), a different way to approach the data is to look at averages. In the following plots, the data has been divided into 36 boxes of size 0.25x0.25. The Likert ratings were counted for each of the boxes and then divided by the number of ratings in that particular box, resulting in an overall average.

It appears that the game felt most *twitchy* with high acceleration values ($>$ 1 second) and low deceleration values ($<$ 0.25 seconds) (see Figure 12). This might be due to the feeling of having slow acceleration, but when releasing the button, the avatar stops very suddenly.

Looking at Figure 12, it seems like the game felt relatively fluid overall, especially with acceleration values above 0.75 seconds. However, with deceleration values above 1 seconds, it seems like the game feels less *fluid*, even though the deceleration phase is longer and thus slower.

Considering the *stiffness*, Figure 12 suggests that deceleration has a bigger influence. Values above 1 second resulted in the game feeling more *stiff*. This can be understood in the sense that the avatar is slow to decelerate, or in other words, feels *stiff* to move around.

The *floaty* aspect seems to be influenced more by the acceleration, since values above 1 second yields a more *floaty* feel (see Figure 13).

Figure 13 depicts the *responsiveness*. As already evident with the previously-shown quotes, low acceleration and deceleration generally makes the game feel more *responsive*. It is interesting, though, that even if the acceleration values are relatively high, as long as the deceleration stays around 0.25 seconds, participants still reported the game to feel *responsive*.

Looking at how *enjoyable* (see Figure 13) and how much participants *liked* the controls (see Figure 14), there don't appear any strong tendencies.

Lastly, Figure 14 suggests that the game feels most *difficult* and *frustrating* with higher values in general, which is to be expected, since the time from input to feedback is longer and thus makes the avatar more difficult to control.

5.2.5 *Curves*

Another way to visualize the data is to take the averages of the acceleration/deceleration values for each of the ratings, e.g., the average acceleration/deceleration values for *twitchy* rating 1, rating 2, rating 3, etc. However, since a Likert scale consists of ordinal values, there is no guarantee that a rating difference of 1 represents an equal conceptual change, since the scale might be used differently by different participants. For instance, some participants might be hesitant to use the extreme values 1 (*not at all*) and 7 (*a lot*), while others might spread their answers across the whole scale [4]. Because of this, in the following graphs, the averages have been put into three weighted categories, so that the extreme ends contribute more. The *low rating* curves consist of ratings 1 (70%), 2 (20%) and 3 (10%). The *mid rating* curves consist of ratings 3 (25%), 4 (50%) and 5 (25%). The *high rating* curves consist of ratings 5 (10%), 6 (20%) and 7 (70%). Using these numbers, it is possible to draw acceleration/deceleration curves, as seen in Figures 16, 17, 18 and 19. For all curves, the sustain time is 1 second. The numbers in square brackets represent acceleration and deceleration values.

At first glance, many of the curves seem similar. However, when comparing the three curves from the same word, there are some differences. For instance, there is a difference of about 360 milliseconds between the deceleration in *low rating* and *high rating* in the *floaty*. curve. Also, it should be noted that the different curves are not mutually exclusive, i.e., the controls can feel *floaty* and *fluid* at the same time.

5.3 Post-questionnaire

After completing the fourth round of the game, participants were asked to complete a Google Forms questionnaire. At the time of writing, 153 participants have taken part in this post-questionnaire. Participants were asked to answer questions about what they thought changed between each round in the game. Even though only the acceleration and deceleration changed, the participants might have perceived more than this. Participants were also asked to try and define the feel of games, in general, with their own words. Additionally, they were asked to describe the feel of six commercially-released platforming games. This was to get a better understanding of how players describe game feel for platformers in general. The six games can be seen in Figure 20.

Figure 21 shows what the participants thought had changed between the rounds. Even though only acceleration and deceleration changed, participants also perceived other changes as well, most notably changes about how the controls felt in the air, such as how gravity and jumping worked. This might partially be due to the variable jump that some players may have missed in the first few rounds. Some also focused on the ball's properties, such as its mass and how "ball-like" it behaved. In regards to acceleration and deceleration, more than double as many mentioned acceleration. When looking at the responses, it seems like participants were unaware of

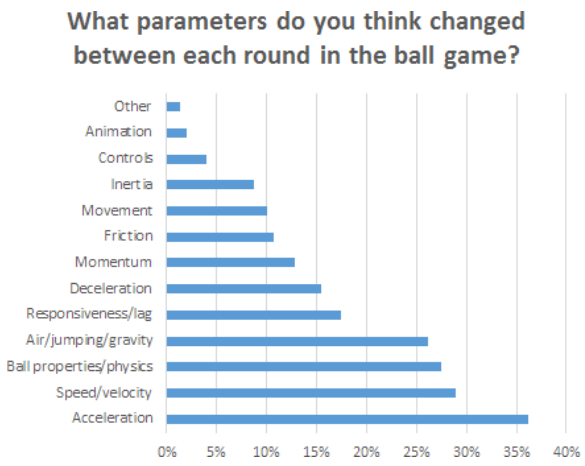

Figure 21: What the participants thought changed between rounds.

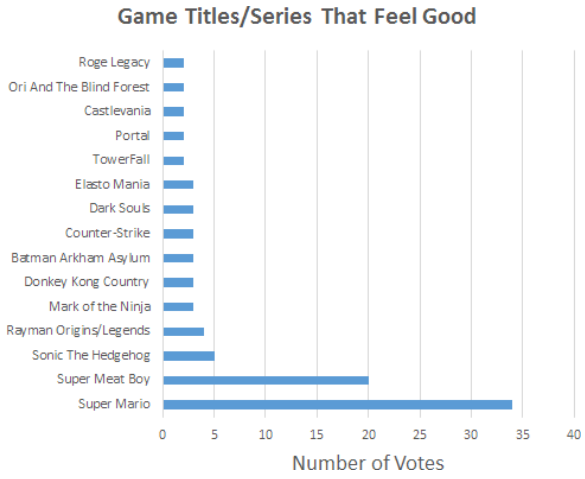

Figure 22: Game titles/series that the participants though feel good. Only those with more than one vote are included.

Table 8: The 30 most commonly-used words to define game feel in general. Numbers in parenthesis indicate usage frequency. Common grammar words have been excluded. Words with duplicate entries such as *games* and *game* have been combined into one.

game (193)	feel (160)	control (87)
how (46)	like (42)	player (34)
good (26)	way (23)	character (22)
really (18)	too (18)	something (17)
should (17)	me (17)	play (16)
gameplay (13)	responsive (13)	don't (13 times)
get (13)	question (12)	easy (11)
world (11)	bad (11)	responsiveness (11)
will (11)	between (10)	actions (10)
time (10)	important (10)	playing (9)

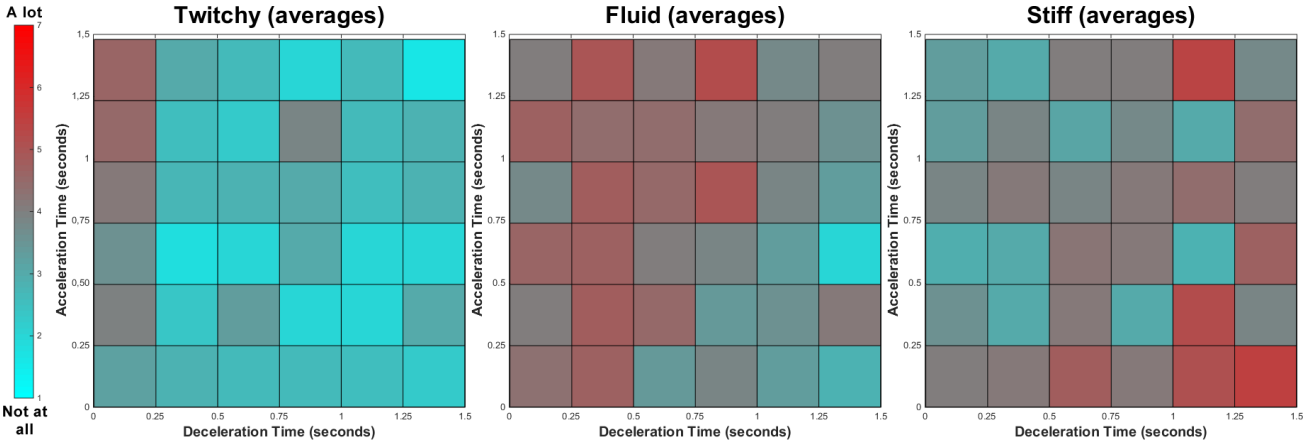

Figure 12: Participants' average responses. Each box is 0.25x0.25 seconds.

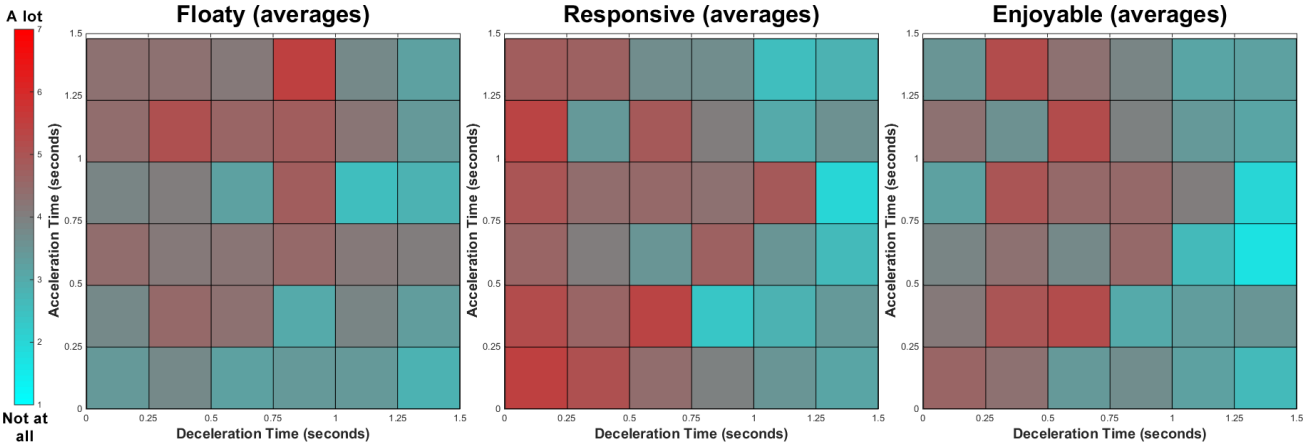

Figure 13: Participants' average responses. Each box is 0.25x0.25 seconds.

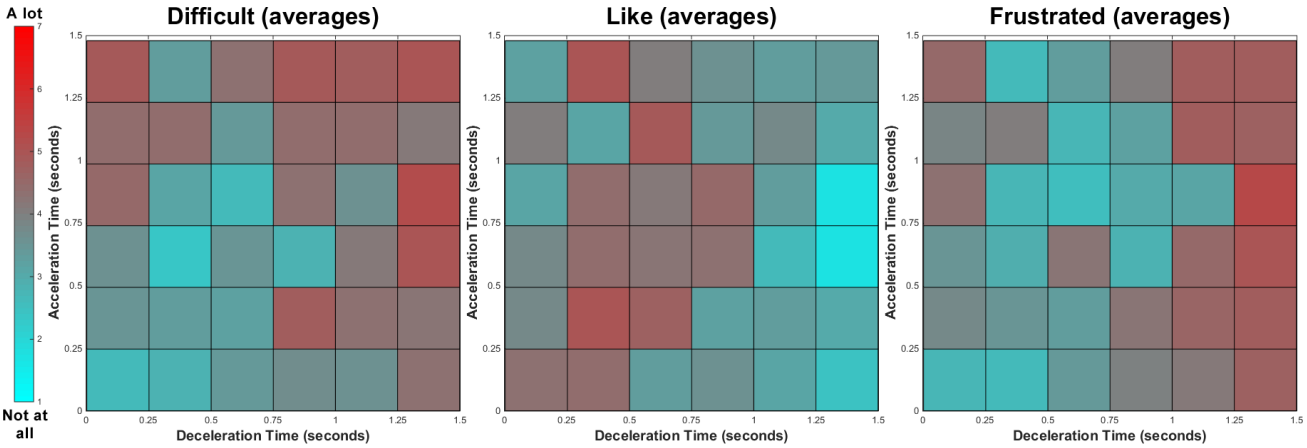

Figure 14: Participants' average responses. Each box is 0.25x0.25 seconds.

the term *deceleration*, often times talking about how the ball gradually would slow down to a halt.

Figure 22 shows the games that the participants think feel good. Even though the question was phrased as *Name one game you think feels good (different from the ball game you just played)*, many thought that they should name a 2D platforming game.

Table 8 shows the 30 most-commonly used words that participants used when trying to answer the question *In your own words, how would you define the feel of games?*

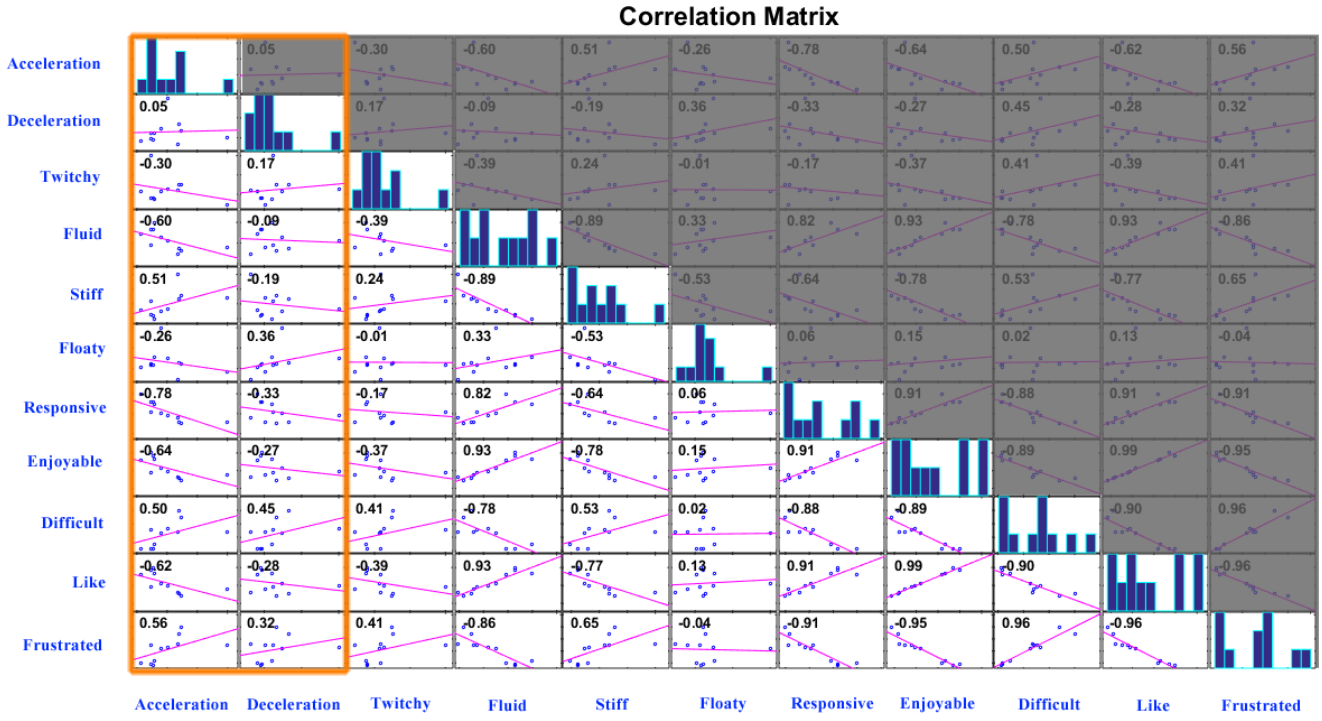

Figure 15: Pearson correlation matrix.

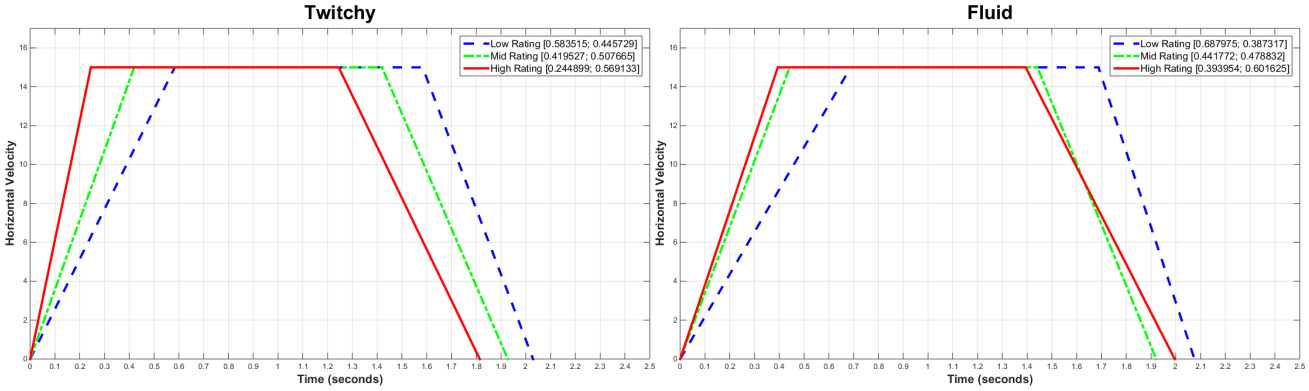

Figure 16: Twitchy and fluid curves.

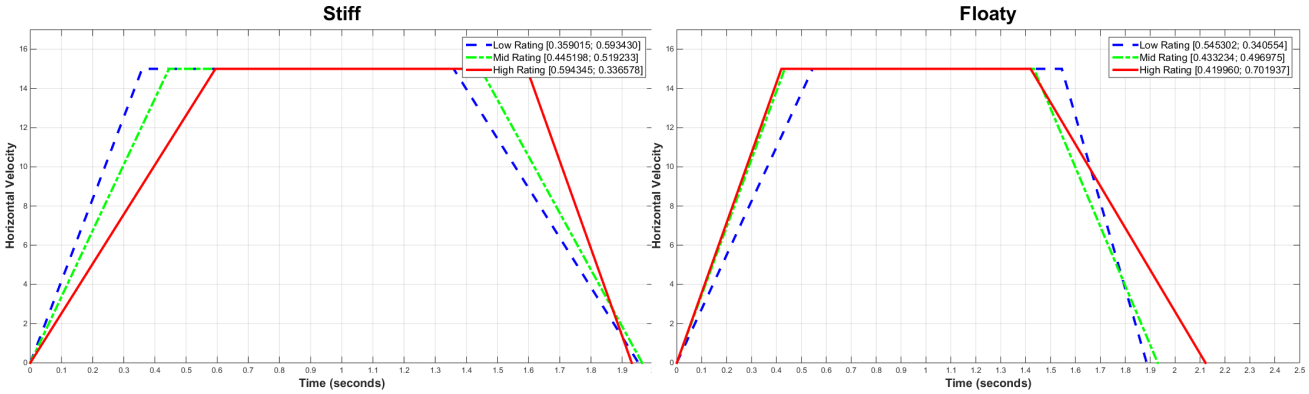

Figure 17: Stiff and floaty curves.

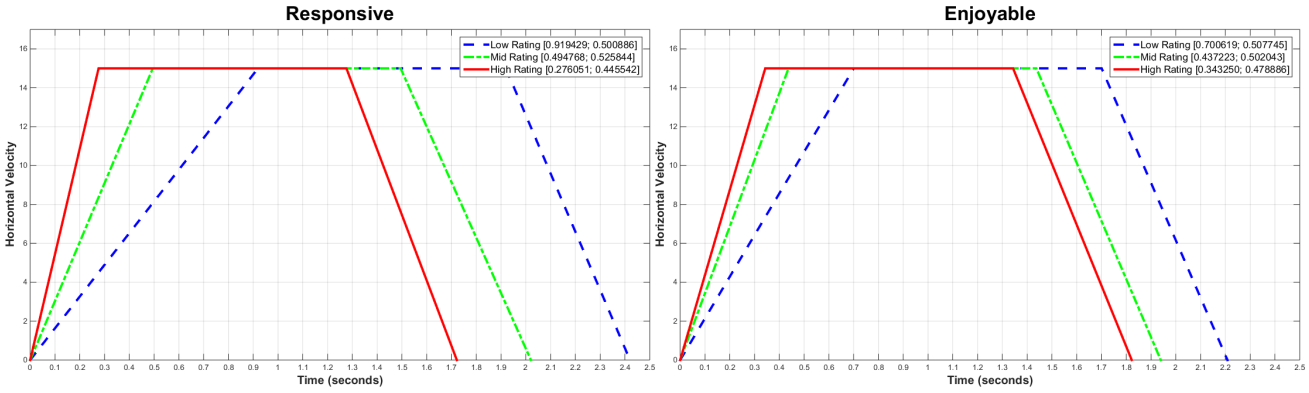

Figure 18: Responsive and enjoyable curves.

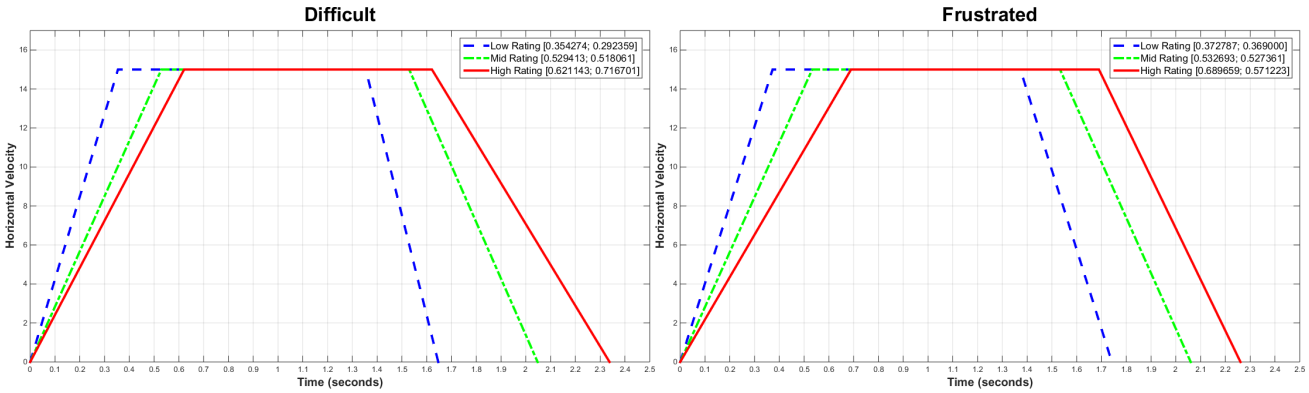

Figure 19: Difficult and frustrated curves.

Participants were also asked to decribe the feel of six platforming games. Below are some selected quotes for describing the feel of each (some quotes have been combined for the sake of clarity).

Mega Man (1987)

- Very responsive and you feel in control in general. It does lack on game feel, though, because some jumps require pixel-perfect positioning which makes you think actively about mechanics.
- Stiff, rigid, bland, cold, futuristic, direct and robotic.
- Very slow and floaty. However, the game is based around moving slowly and attacking from a distance. The jumping is floaty, yet responsive to player inputs, such as changing direction in midair, or stopping the jump early.
- Responsive, since Mega Man moves when you press the button, and stops when you don't. The game, however, sometimes feels a bit clunky since you can only shoot straight, but the level design makes up for this most of the time.
- Very solid ground and air control. You have proper air control and Mega Man doesn't stop at the exact moment you let go of the D-pad. He slides a few pixels further, which feels natural.
- Super tight, super retro, no wiggle room. The fact that Mega Man stops completely when you let go of the button takes a bit of getting used to, but allows for precision in ways you wouldn't expect. Our brains are wired for natural physical projectile motion (i.e., parabolic), but Mega Man forces you to ignore that, which takes some getting used to.

LittleBigPlanet (2008)

- Incredibly floaty to the point where it just isn't enjoyable. It feels like you have NO control over the character.
- Floaty and squishy, inertia-based — character has sense of inertia — height and length of jumps are determined by speed of character movement and button press duration.
- Nice and fluid. Sort of "organic". Everything moves naturally according to things like gravity, force-impact, etc.
- Just terrible to control. Everything about the controls is too floaty, making precise jumping a chore. A lot could have been improved by enabling D-pad controls, as the analog sticks tend to increase the floaty feel, and it's generally much more imprecise for this type of game.
- Game is very responsive but the control schemes are convoluted and overly complicated.
- Laid back and relaxed. It's fun and easy, it's responsive and the controls are pretty straightforward.
- The slightly imprecise nature of the platforming makes for interesting mistakes to occur when playing with friends, but it is not so egregious that it is game breaking.

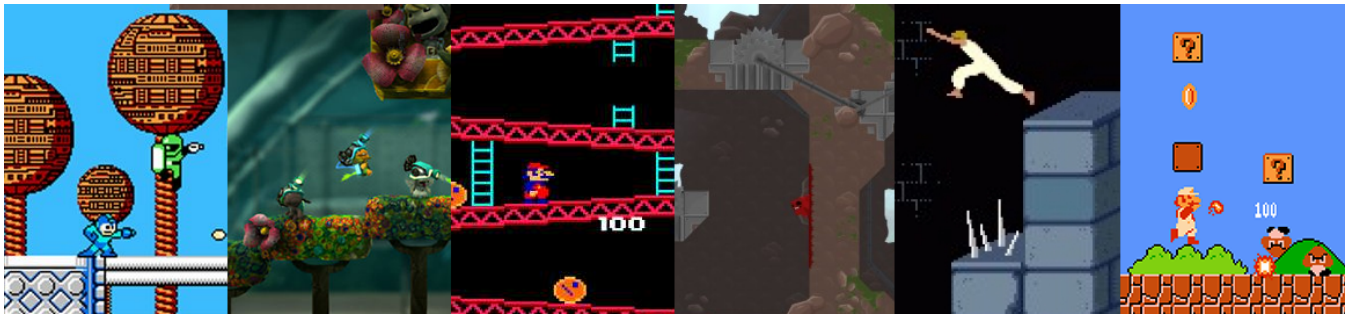

Figure 20: Participants described the feel of six platforming games. From left to right: *Mega Man*, *LittleBigPlanet*, *Donkey Kong*, *Super Meat Boy*, *Prince of Persia* and *Super Mario Bros.*

- Child-like. Super happy. The animations really make a huge difference in how this game feels.

Donkey Kong (1981)

- A bit sluggish, lends either a feeling of panic or frustration to me depending on whether I win or lose. Mario feels a bit difficult to control, the jumps are hard to gauge and he never seems to move quite quickly enough. It feels like slogging through a chest-high swamp.
- Good decent controls. It's very precise with no room for errors. But completely lacks any kind of air control. Mario is definitely floaty, but with almost slow-motion jump physics.
- Mario feels responsive on the ground, if a bit slow, but his jumping feels far too floaty, and he's locked into his jumping trajectory, which almost never works in a game centered around jumping over obstacles and pits.
- Squarish — hard to explain.
- Direct, unforgiving, repetitive, snappy.
- Precise and sloppy. Two words wide from each other, but it's the best I can describe it. It requires precision to jump the barrels, and the controls and overall feel provides that, but in the same time, it doesn't feel like you got much else control of Mario.

Super Meat Boy (2010)

- Smooth and fast-paced movement that requires skill. Very good acceleration and deceleration of the character. The air control feels natural and is influenced greatly by the character's momentum.
- Fluid, precise, controlled, reactive, tight, streamlined.
- Raw, brutal, unforgiving, sarcastic, energetic.
- Meat Boy is slidey on the ground, but sticks to the walls, making the wall jumps almost like beats in the rhythm of the game. Responsive, slippery but consistent.
- Fun because the controls are very easy to use and learn. And very intuitive too. Also the graphics sound/aesthetics match the game and the controls very well somehow.
- Free, fluid, unstoppable, flowing. Smooth and comfortable.
- Massively floaty. The controls are often hailed as "tight", but that only seems to come from the responsiveness, not the actual movement physics, which are very floaty and unpredictable.
- Part of the game feel is sound design. In Meat Boy, you see him run up to speed, and as he gets faster you hear his little wet footsteps. It's rewarding to the player to get that feedback, it makes you FEEL fast. If Meat Boy was a red featureless square with no sound, it'd be a vastly inferior 'feeling' game.

Prince of Persia (1989)

- Super limited. Static animations, no chance of survival. It's more of a strategy game than a platformer, honestly.
- Old and mushy. You can't really control your character easily, and the controls don't feel responsive.
- The controls are very difficult to master because when you stop pressing a button the prince will still be moving, and therefore it is very hard to time you jump. One of the rounds in your game had the same kind of feel.
- Controls are responsive, but the movement is completely unpredictable due to the environment seemingly actually affecting the velocity and acceleration of the character, where it normally would just intervene in other games. More apparent rules for the character's steps or jump lengths would help tighten the game feel, but as it stands, it's very weighty and unpredictable.
- Slow, imprecise and sloppy as hell. You would have to play around the controls, and have it in mind all the time.
- Prince of Persia was absolutely amazing when it came out. The body dynamics were unlike anything I'd seen in a computer game before. It was sometimes hit-and-miss with the timing of jumps, but overall very responsive.
- Great controls. Tight and a yet a good sense of weight behind the character.
- Adventurous. Unforgiving, slippery.
- Squarish and clunky, but also very responsive — but in a weird sort of unresponsive way

Super Mario Bros. (1985)

- It feels very responsive. Actions are quick and takes zero effort to master.
- Fast and loose.
- The movement is a bit clunky, since Mario slides around, but it's okay, since the game doesn't have many big precise jumps.
- Floaty, awkward jumping and running. Momentum really holds and it feels like you are piloting a brick.
- Tight, predictable acceleration and momentum velocities. Instantly responsive controls, and although the

character portrays a lot of acceleration and momentum after having stopped, it's always the same, becoming predictable and thus, enjoyable.
- A bit draggy — slow acceleration and long jump time.
- Fairly responsive but a bit twitchy because Mario's movement in midair is difficult to control. The capacity to run by pressing one button is clever as it provides a better move control for difficult parts.
- Simple and predictable. No stress. You can focus on tasks instead of the controls.
- The run button pretty much allowed you to switch between two separate feels, one slow and one fast.
- Slow to accelerate, but the levels are designed around it. Top speed is fast, jump arc is nice (the top of it is weird, he hangs there a bit, outside of a standard arc). Basically, Mario gives you the freedom to go slow or fast, and provides enough wide open space for it to feel good.
- Perfectly middle-of-the-pack in terms of physics. A little bit slippery and a little bit floaty, but not noticeably so in either category.

As the above quotes illustrate, players tend to focus on different elements when it comes to game feel. What feels 'unresponsive' and 'floaty' to some may feel more responsive and relaxing to others. It all depends on the context of use, as one participant expressed when describing the feel of *LittleBigPlanet*. If playing in a casual/social setting, it might not matter that the feel is 'floaty' and 'imprecise': *"The slightly imprecise nature of the platforming makes for interesting mistakes to occur when playing with friends"*. It all comes down to what type of game it is and how challenging it's supposed to be. For instance, one participant described the feel of *Super Mario Bros.* to be 'clunky', but found it acceptable, since the game doesn't feature many big and precise jumps.

Some also mentioned the usage of animation and sound effects, which again confirms that game feel is about the overall player perception. In general, as shown in Figure 23, most participants find the feel of games very important.

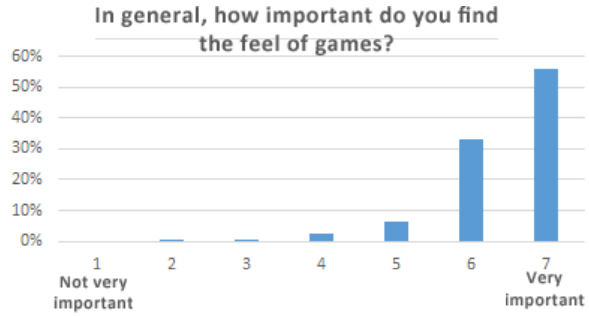

Figure 23: Participants found game feel to be quite important.

6. DISCUSSION & CONCLUSION

When it comes to how people describe game feel in their own words, it seems that many use basic descriptions such as 'heavy', 'slow', 'responsive', 'realistic', 'sluggish' and 'floaty'. For the type of game used in this project, those descriptions might be enough to describe the game feel.

While some participants seemed quite sensitive to even smaller changes, others reported that they didn't feel any difference between the rounds.

The curves presented in this paper are based on averages. The results are thus less clear when compared to those provided by Swink (see Section 3). In this experiment, participants were asked to rate the acceleration and deceleration time values along a group of Likert scales. An alternative approach would be to use A/B testing and ask participants whether stimulus A felt more or less 'twitchy' than stimulus B. It would also be interesting to let players tweak and tune the game's parameters in order to achieve what they think feels best.

Furthermore, one could look into more evenly-distributed sequences of the stimuli, e.g., within the 240 ms interval. It might also be interesting to look into non-linear curves and the influence of how responsive these curves might feel (e.g., a slow acceleration that starts with an initial bump in its curve).

It appears that some participants were confused by the term *game feel*. This is to be expected, since it's still a loose and relatively unknown concept about how players perceive games. A similar term, *mouthfeel*, describes, as the name suggests, the sensation of food in the mouth. Even though the term was coined in 1951 [12], it is still a relatively unknown concept. It might take a while before game feel finds its place in the vocabulary of the common game player.

Putting words on the feel of anything is difficult, as one participant expressed in the post-questionnaire: *"Sorry if my answers weren't super specific. I was having a bit of a hard time finding the words."* Another participant wrote that 'feel' is a very non-specific word: *"Outside of games, 'feel' is a very non-specific word, and is used for communicating all the stuff that is hard to communicate. I come from a design background and to me 'feel' is used when describing the overall feeling I get from a thing when I can't pinpoint why I get that feeling (like, a strawberry is just cute, and I can't say directly why)."* Additionally, a different participant points to the fact that game feel depends on the context: *"I think the feel depends on the game. If we control a soccer ball on a platformer, faster and more responsive controls make sense, but if it was a bowling ball, it would be better to be a little more slow and 'draggy', as long as the levels and obstacles are designed with this in mind."*

Game feel is a holistic experience with many contributing factors. In this experiment, only the avatar movement was considered. However, all other elements still indirectly influence the overall game feel, such as the rolling animation of the ball; the gravity and jumping mechanic; the level design; and the input device. It is unclear how big an influence the altering acceleration/deceleration has over these other factors, as well as other contributing elements such as the attention, mood and motivation of the player. Further research into the influence of these is required.

7. ACCOMPANYING VIDEO

A video has been put together in order to describe game feel and this project: `http://youtu.be/S-EmAitPYg8`.

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