MSc Thesis Interaction Technology

# Sneakily Purposeful Games: A new design strategy for motor-based serious games

Joep W. Eijkemans

Supervisors:
dr. ir. Dennis Reidsma
dr. ir. Robby van Delden
dr. ir. Ton Spil

March 23, 2023

Department of Human Media Interaction
Faculty of Electrical Engineering,
Mathematics and Computer Science

UNIVERSITY OF TWENTE.

# Contents

## About this report

This report presents a new strategy for the design of serious games, with the primary goal of enhancing the typically low entertainment value that these games offer. In order to evaluate / validate this proposed design strategy, a game will be developed following this method that will serve as a case study. The development process of this game and the subsequent experiment performed to evaluate the gaming experience that it offers are also described in this report. Since this report is rather long and detailed, I felt compelled to give some notes / tips that might help readers navigate it beforehand.

Firstly, this report employs 2 different citation methods, the traditional IEEE style using only a number, and a variant that uses 'NS', followed by a number. This distinction is based on whether a source is considered scientific or not. Scientific sources such as scientific articles, conference proceedings, and books are marked using only a number, whereas non-scientific sources such as web articles or video essays use the NS prefix. The non-scientific sources can generally still be considered expert opinions but are still marked as non-scientific for transparency's sake. Non-scientific sources will become more prevalent in the development phase of the case study game (Sections 5 and 6), since most game design decisions are inherently subjective, without a clear right or wrong answer. However, there is still a rationale behind these decisions, which is often based on principles presented in these types of sources.

It's also important to note that, when using the digital version, a lot of elements in this report can be interacted with. Images can be clicked to enhance them, references to other sections can be clicked for easy navigation, citations can be clicked[1], etc.

Lastly, for those who are interested, the case study game is still available for download using this link.

[1] This is only true for scientific citations. Citations that use the NS prefix cannot be clicked.

# 1 Introduction

Serious games have become both a growing market in the videogames industry [164, 234] and a field of academic research [209, 129, 204]. Although, together with other sedentary pastimes like watching television or internet browsing, videogames have a reputation as a leisure activity with little to no beneficial outcomes [189, 99, 170], modern computer games show potential not just for engaging and entertaining users, but also in promoting learning [129]. Serious Games represent an acknowledged potential for instruction, which is largely attributed to their ability to motivate learners [20, 117], both adults as well as children [93].

However, although the effectiveness of serious games has been studied thoroughly (e.g. [36, 67, 142, 146, 210]), the enjoyment of such games has received much less attention than their educational outcomes [226]. Although many authors seem convinced of the effectiveness of serious games (e.g. [129, 135, 59, 200, 238]), the experimental evidence in favour of this position is meagre [93]. It is often assumed gameplay will be enjoyable, regardless of its (serious) contents [226]. Yet, there are studies that reported low enjoyment values of serious games, despite their successful educational impact [95, 226, 262]. This downside is not at all uncommon among these so-called edutainment games; many are developed on a tight budget and suffer from poor game design and presentation [172]. The fun experiences elicited by these games are rather limited, and the hope that players would select those games and deliberately play them is often not fulfilled [172].

This poses a problem for serious games, as fun is one of the most important characteristic of a good game [197]. Fun element helps maintain learner interest and positive attitude [129], and promotes (intrinsic) motivation [129, 58, 72, 165].

There exist a number of theories that aim to explain this phenomenon. Some hypothesize that by simply labelling games as 'serious' or 'educational' may reduce their appeal to some players [226, 32, 196].

Others [117] speculate that, since serious games tend to be more goal-directed, rather than just being for fun and enjoyment, they clash with classical game theories like those of Huizinga [113] and Caillois [40], which state that enjoyment is primarily attributable to a game's freedom from utility.

Gredler [100] states that persuasively linking the enjoyment of the game to the learning process is critical. Resnick [205] criticised learning games for rarely achieving this, and their inventors for tending to regard learning as "bitter medicine that needs sugar-coating". Doucet and Srinivasan [65] also support this notion, stating that "many educational games do not properly translate knowledge, facts, and lessons into the language of games. This results in games that are often neither engaging nor educational".

Some seem to conclude that learning and gaming simply don't mix very well. According to cognitive load theory, the critical factor is to keep the extraneous (distracting) cognitive load to a minimum while maximizing the germane (learning-related) load [223]. Fun-related aspects of games are generally considered to be distracting, rather than learning-related, but this may vary depending on the game and its mechanics [206]. A notion supported by Clark [50], who mentions that intended learning outcomes and game objectives might conflict and that games can distract from the learning content. Lazzaro & Keeker [141] also touch upon this phenomenon, stating how "games are typically designed to put challenges to reach outcomes, and the outcomes themselves are not necessarily the most rewarding aspect, but the process of achieving these outcomes, while productivity-related applications are designed to prevent challenges, and the outcome is the most rewarding aspect".

Most likely, all of the abovementioned reasons play a role. Due to the enormous variety in (serious) videogames, their intended serious purpose, their intended playerbase, and many other variables, it's hard to find a definitive answer as to why serious games tend to be less fun compared to their non-serious counterparts. Personally, I think that this problem is usually the result of serious games trying to be two things at once; serious and fun. When developers set out to achieve more than just one goal, it becomes a possibility that conflict between the goals arises. Enhancing the seriousness of a game inevitably seems to decrease the fun, ludic experience the game offers, and vice versa. Shen et al. [226] states: "The assumption that serious games can be modeled the same as entertainment games may not hold true. The educational enrichment may require changes in fundamental game features that ultimately compromise the entertainment experience". Serious games prioritize education over entertainment [166, 163, 169]. This fundamental problem is often enhanced by short development times and budget constraints [172].

Development costs are one of the major drawbacks of instructional tools, and as such, strategies that support the efficient development of effective serious games are a huge concern for research [7]. Despite attempts to define frameworks or models for serious game design [135, 59, 256, 238], there is currently still a need for tools / methodologies that enhance the development of serious games [51]. However, lowering the development costs of serious games is not the primary goal of this report, although it might still happen as a side effect (see Section 3.3.1). The primary goal of this report is to create a design strategy for serious games that is able to create games capable of serving a serious purpose whilst maintaining entertainment / fun levels comparable to regular, non-serious videogames.

Learning (or other serious goals a game might have) and fun are not necessarily mutually exclusive though, and there is ample evidence that shows serious games can still fulfill our entertainment desires [226, 20]. But, I personally believe that the current design methods have allowed the serious aspects of these type of games to hamper their entertainment value too much. Simply tacking some educational aspect to some game mechanics and hoping it doesn't diminish the fun of the game is not an effective method for serious game design. Breuer et al. [32] appears to share this opinion, stating that "despite the similarities between games and learning, it is not sufficient to just assume that all forms of games are equally suitable for learning and that simply presenting material in a game-like setting will increase the quantity and quality of learning".

The ideal serious game combines entertainment and learning (or other serious goals) in a way that the players / learners do not experience the learning part as something external to the game [32]. The most successful serious games have a blended learning experience which seamlessly integrates enjoyment and learning and presents the learning content as something which is neither external to the game nor a juxtaposition of entertaining sequences and educational material [32]. There does not appear to be a design strategy that allows developers to pursue that optimal blend of seriousness and fun in a systematic way, and as a result, serious games tend to suffer from the abovementioned problems.

This report proposes a new strategy for serious game design with the ultimate goal to enable developers to create games capable of serving a serious purpose without compromising their fun or entertainment value. In addition, a case study game will be developed and subsequently used in an experiment to evaluate the validity of the newly proposed design strategy.

The remainder of the report is structured as follows: Section 2 discusses different methods of categorizing serious games in order to clearly define which types of serious games are best suited for the proposed design strategy. Section 3 explains the inner workings of-, and rationale behind the proposed design strategy. Section 4 then introduces the primary research questions. Sections 5 and 6 relate to the development process of the case study games, with Section 5 outlining the primary requirements and Section 6 explaining some of the main design decisions. Section 7 discusses the design and setup of the experiment and Section 8 delves into the results of said experiment. Section 9 lists some factors that may potentially have negatively influenced the validity of the experiment data. The final conclusions are drawn in Section 10. Lastly, Section 11 outlines some possible interesting ideas for future continuation of this project.

# 2 Categorizing Serious Games

This chapter proposes a simplified method of categorization for serious games supported by examples, and discusses for which types of serious games the newly proposed design strategy will be most applicable.

## 2.1 Method of categorization

Given the apparent complexity of the issue, it's important to first specify the types of serious games this strategy will target. 'Serious Games' is an umbrella term that encompasses many different types of games [204], and it seems unlikely that there is a one-size-fits-all design strategy that works for every single possible serious game. Some categorization is needed.

However, the huge variety of (serious) games and at times vaguely defined genres makes them notoriously hard to categorize [93, 269]. Therefore, we first turn to regular games to find inspiration for a productive categorization. Regular, non-serious videogames are often categorized into genres. The most common (non-serious) videogame genres are adventure games, puzzles, role-playing games (RPG), strategy games, sports games, and First-Person-Shooter games (FPS) [184, 32]. Note that further categorization is also possible (e.g. Wolf [261], who defined 42 different genres). Genres like these are the most common way to give product information about videogames to the customers [29][NS53]. Genres can even influence gameplay by affecting the affordances of in-game objects (e.g. Spike traps should generally be avoided in platformer games like Blasphemous, but can be very helpful in tower defence games like Bloons Tower Defence 5) [21].

Whilst serious games could also be categorized into genres, most often they are classified by the type of serious purpose they serve. Although this does somewhat emphasize the previously-identified problem of prioritizing the serious aspect over gameplay, it does make sense: A strategy game that aims to teach math to children aged 5-8 will play very differently compared to a strategy game that aims to enhance creative thinking and cooperation for businessmen, despite being the same genre. Not all genres are equally appropriate for learning / serious games [244, 32].

Still, even when classifying serious games based on their serious aspect, there doesn't seem to be a universal standard to do so: Micheal and Chen [163] classify serious games into a set of markets: military-, government-, educational-, corporate-, healthcare-, and political-, religious-, and art games. Zyda [271] states that serious games can be applied to domains as diverse as Healthcare, public policy, strategic communication, defense, training, and education. Rego et al. [204] lists corporate and military training, health, education, and cultural training as examples of diverse areas of application for serious games. Wikipedia identifies 10 categories (health, exercise therapy, politics culture & advertising, security, military games, recruitment games, product creation games, adult education, youth education, and art games) [NS67]. Grendel Games, a Dutch company focused on the development of serious games, distinguishes 5 types of serious games (games that: transfer knowledge, teach skills, create awareness, change behaviour, or increase motivation) [NS28]. Yet another source [NS21] distinguishes 2 types of serious games (process-oriented and outcome-focused).

For simplicity's sake, I will propose my own method of categorization which categorizes serious games into 3 distinct types: Educational / Cognitive, Emotional / Social, and Motor-based. The distinction between these categories is based on the serious goals a game has, and, by extension, the way in which serious goals are implemented within the game context (e.g. educational games tend to mix the educational aspect into the context of the game whereas, for motor-based games, the serious aspect is typically the physical motion happening in the real world, and not implemented within the game context).

Although this method of categorization is but a surface-level approach that ignores a lot of the complexity of the issue, it is sufficient for gaining a better understanding of which types of games the proposed design strategy is best suited for. But note that further categorization into subcategories is often possible, and category hybrids (or hybrids within categories) can still exist. For example: 'Racketeer' [252] aims to improve both mathematical skills (educational / cognitive) and cooperative skills (emotional / social), or the 'Workout Game' mentioned in [77], which promotes exercise for elderly (motor-based), but also contains a significant social element in the interaction between the user and the robot (emotional / social). An argument could also be made that relationship building are skills that can be taught, practiced, and tested, and should therefore fall under the 'Educational / Cognitive' category. The distinction here is that Educational / Cognitive serious games tend to aim to enhance the player's knowledge and skills within a certain topic whereas Emotional / Social serious games aim to change the players' behaviour.

Developers are not, and should not be, limited by the characteristics of the category or genre that their game fits into. In my opinion, some of the best games are the hardest ones to categorize; the ones that intentionally break preconceived notions or unwritten rules players might expect a certain game to follow (e.g. Undertale intentionally reverses some classic RPG mechanics).

Categorization is a great tool for analysing games and conveying information to potential customers [29][NS53], but not as a starting point for development, since it imposes limitations on the developers' creativity. However, when developing a design strategy that is expected to be well-tailored for some games but not for others, it is important to understand which characteristics of a game influence this relation, and, by proxy, which types of games generally contain a lot of the characteristics that make them suited for this strategy and lack those that don't suit it very well. This is what this categorization aims to achieve. The relation between certain game characteristics and how well-suited they are to be designed following the proposed design strategy is discussed in Section 2.2. The remainder of this section is dedicated to defining the different categories of serious games, as well as providing examples of which types of games fit which category.

### 2.1.1 Educational / Cognitive Serious Games

Educational / Cognitive games focus on teaching, training, or testing new knowledge or skills. Most of the current serious games fall into this category [32, 166]. Some examples of educational / cognitive games include:

- Games designed for education (e.g. math games like 'Darts', a computer game designed to teach fraction concepts to elementary students [66, 155], or 'Garfield's Count Me In', which has children doing repetitive arithmetic exercises [NS27])
- Simulation (sim) games (e.g. 'Microsoft Flight Simulator', which was designed to be a comprehensive simulation of civil aviation [NS32])
- Games about politics, business, and culture (e.g. business simulation games or tycoon games like 'OpenTTD' in which players try to earn money by transporting passengers and freight via road, rail, water and air [NS1], or 'Darfur is Dying', which helped to shed a light on the war in Darfur and the consequent humanitarian disaster [NS32].)

### 2.1.2 Emotional / Social Serious Games

Emotional / Social games primarily focus on the emotional well-being of the players, enhancement of social skills, or relationship building. Some examples of emotional / social games include:

- Games that aim to enhance social skills for children with ASD (Autism Spectrum Disorder) (e.g. 'ECHOES' by Bernardini et al. [24], which aims to improve learning and communication in children with ASD using an avatar, or 'Racketeer', a game with the purpose of improving mathematical- and cooperative skills in children with ASD, developed by Van Veen et al. [252].)
- Exposure therapy games (e.g. the virtual reality game to help reduce arachnophobia (fear of spiders) from Lindner et al. [147])
- Relaxation / meditation games (e.g. the 'Frozen Bubble' adaptation from Parnandi et al. [188] that enables relaxation training through respiratory biofeedback)
- Social games for elderly (e.g. 'TableTalk', a senior-friendly online poker game by Shim et al. [227], 'AgeInvaders', a concept for an intergenerational game with a major social aspect by Khoo et al. [134], or even something as simple as 'Bingo')

One important note here is that virtual environments (e.g. VR exposure therapy, virtual environments for relaxation) aren't necessarily always games. Although virtual worlds are often confused with games, they lack the typical elements most commonly found in games - such as: enemies to beat, levels to attain, a storyline, goals to achieve, and the possibility for a character to die [8, 269]. The examples given above do contain elements and mechanics that classifies them as games.

### 2.1.3 Motor-Based Serious Games

Motor-based games focus on body movements and are often used to promote or enhance exercise or to support physical rehabilitation. Some examples of motor-based games include:

- Games that promote movement / exercise (e.g. Sony's 'EyeToy' and Konami's 'Dance Dance Revolution', which Lanningham-Foster et al. [138] concluded were both useful for obesity prevention and treatment, the 'Wii-habilitation' games mentioned in [189], 'SilverPromenade', a game that encourages eldery to go on virtual walks [91], or 'Otago Exercises', which Marin et al. [157] used for improving the physical health of elderly)
- Games that aid physical rehabilitation (e.g. the Xbox-based physical rehabilitation system presented by Morrow et al. [174], or the online multiplayer game 'Second life', which Galego and Simone [83] combined with a Wii remote control into a virtual rehabilitation system.)

## 2.2 The focus of this report

The proposed design strategy in this report will focus on the last category: Motor-based serious games. An important reason for this is that, for almost all Educational / Cognitive and Emotional / Social serious games, the serious element is implemented within the context of the game (although there are some exceptions, especially within the social games category, where the serious element often depends on player actions in the real world). Because the serious aspect needs to be integral to the game and gameplay itself, it is not well-suited for a design strategy that intentionally ignores this aspect for most of the development time (see in Section 3). In contrast, most of the serious gameplay happens outside of the game for motor-based serious games: There is the virtual game, and then there is the real, physical world, where the movement happens. The two can be separated, which is integral to the success of the proposed design strategy.

As a result, motor-based serious games tend to distinguish themselves the most from the other 2 categories. An educational game and a social game can be played in a very similar manner, but motor-based gameplay is always unique, adding a whole new layer of complexity to the games in this category. Most literature focuses on educational games [32, 166], and the conclusions drawn from-, and practices based on this literature may not hold true for motor-based games.

Within this category, the primary focus of the design strategy will be on (physical) rehabilitation[2]. Promoting movement and exercise can also be done using (serious) games (e.g. Wii games, Dance Dance Revolution), but these games often don't suffer from the lack of fun / motivational problems this new strategy aims to solve [145, 229]. Games that enhance exercise also exist (e.g. the game created for use by Olympic athletes to allow training prior to the 2012 Olympics mentioned in [224]), but these games are often required to be very specific in order to achieve their goals. This also prevents them from being broadly applicable. Therefore, the design strategy proposed in this report will focus on the design of serious games for (physical) rehabilitation.

Gunasekera and Bendall [104] define rehabilitation as "a dynamic process of planned adaptive change in lifestyle in response to unplanned change imposed on the individual by disease or traumatic incident". A major problem for physical therapy is that patients often lack interest in performing repetitive exercises and ensuring they complete the program [204, 38]. Current evidence suggests that a significant number of people offered home exercise do not adhere to the program, thereby rendering the intervention ineffective [211]. It has been shown that games can contribute to an increase in both motivation and enjoyment in rehabilitation sessions [204, 248]. Games applied in this field may also have the added benefit of distracting a patient, and can therefore be of help in managing pain [38, 137]. Videogames may also open up further applications and use cases for existing technology such as virtual reality, which has long been used in rehabilitation programs [37, 111].

So, generally, (serious) games could potentially serve as functional tools for rehabilitation therapy. However, as Rego et al. [204] emphasizes; further improvements are needed to attain higher levels of motivation. The aim of the proposed design strategy is to solve this issue by ensuring sufficient levels of fun and enjoyment in these games, whilst preserving sufficient effectiveness of the serious component.

[2] The word 'physical' is between brackets because therapy involving physical motor exercises may be applied for recovery of non-physical trauma (e.g. loss of motor control of upper limbs due to a stroke as exemplified in [38, 150, 42]). When this paper talks about 'physical rehabilitation', it is referring to therapy involving physical (motor) exercises.

# 3 Sneakily purposeful games

In this chapter, the newly proposed design strategy and the primary considerations to its usage are explained.

## 3.1 Summary of the strategy

The general philosophy behind this new design strategy is to make fun games serious, rather than attempt to make serious games fun. The strategy aims to mimic the design process of regular, non-serious games as much as possible, hoping to attain similar levels of enjoyment in the final product. The first step to this strategy is to realize that regular games can serve serious purposes too (e.g. improving motor skills / hand-eye coordination), but somehow still manage to be primarily fun and entertaining; the serious aspect seems to be a side effect caused by actions the player has to perform repeatedly. Then, instead of inputs via a controller or mouse and keyboard, some inputs can be replaced with exercises (e.g. move leg to attack). The inputs the game takes should be specifically designed in such a way that many different exercises can be used as inputs. For the majority of the design and development of the game, these exercises aren't defined. All the developers care about are the inputs, which can just come from a placeholder mouse and keyboard during this period. The focus is to create a primarily fun game, unbiased by the serious aspect. Some considerations need to be made to ensure the game is still suited for its intended use case, but these don't have to hinder the design of the game too much.

Since exercises are only used as input for the game, this strategy effectively separates the serious aspect from the gameplay. This strategy runs counter to the design of most serious games, which aim to balance / blend the serious and fun elements together in the design of the game [32, 232]. Whilst this approach has tremendous theoretical appeal, it's also the approach from which the aforementioned reduced fun / entertainment problem originates [226, 205, 65]. Rather than attempting to balance the serious and fun elements in a game, this strategy separates them, so neither one has to compromise in favour of the other.

There are sources that show that the serious aspect of a serious game does not necessarily need to be embedded in the game design, but can also be assigned to the game by the context it is used or embedded in [39]: "while the learning process takes place via the game, the effect intended by it may well be an exogenous one" [32].

Yet, a challenge remains. Because despite regular, non-serious games' ability to serve serious purposes [32, 47, 228, 232, 250, 99], these serious effects are often mere unintended side effects. They are not guided or designed for by the developers of the game; they arise naturally. However, if your goal is to develop a serious game for a specific purpose / application, you do want to be able to ensure that your game is well-suited for that specific serious purpose. Since the proposed design strategy aims to separate the serious and non-serious aspects of the development, how can developers ensure that the final product is both sufficiently fun and serious, and that the two elements match smoothly together?

Some concessions have to be made to enable developers to guide the serious purpose whilst also preventing it from influencing other game design decisions, potentially at the cost of the entertainment value of the game. The primary one is that the development process requires separation of the player control actions and the rest of the game. This automatically makes the strategy less suited for games that require that the serious aspect is implemented within the context of the game, and is therefore also the primary reason that this strategy primarily targets motor-based serious games.

The other limitation posed by this strategy is the different signal types that can be used as inputs for the game control actions. Different physical exercises translate into different signal types (e.g. squeeze a ball, or move leg in a specific direction at a specific speed). The game should be able to take different input signals so that it can be controlled using a wide variety of exercises. This, in turn, poses new challenges like timing, frequency, and whether or not the actions are even fully controllable by the player (e.g. breathing, blinking). These challenges are described in more detail in Sections 3.2.3 and 3.3.2.

## 3.2 The strategy: Step-by-step

This section explains the proposed design strategy, step-by-step, in greater detail than the quick summary found in Section 3.1.

### 3.2.1 Step 1: Non-serious games can achieve serious goals

The first step to this new design strategy is to realize and acknowledge that regular, non-serious games can also achieve serious goals [32, 47, 228, 232, 250, 99]. Granic et al. [99] summarized that playing videogames can have cognitive benefits (e.g. faster and more accurate attention allocation, higher spatial resolution in visual processing, enhanced mental rotation abilities [101, 247], improved problem-solving abilities [2, 199], and enhanced creativity [118][1]), motivational benefits (e.g. developing a persistent motivational style and a positive attitude towards failure, which predicts a better academic performance [30, 253]), emotional benefits (e.g. improved mood or increases in positive emotion [215, 218], and an increased ability to flexibly and efficiently reappraise emotional experiences [103]), and social benefits (e.g. acquiring important prosocial skills that reward effective cooperation, support, and helping behaviors [73, 89]).

As a more specific, anecdotal example: FPS games such as Call of Duty have made me, personally, really good at spotting semi-hidden targets, quickly moving my cursor (crosshair) on them, tracking them if they are moving, and

[1]This study was unable to conclude whether playing videogames enhances creativity or if creative people are more likely to play videogames

controlling the recoil of the gun. Now, did the developers of Call of Duty design their game specifically to teach their players this, or is it just a side effect that arises from other, more gameplay-related decisions? I think most people will agree with me that it's the latter; a viewpoint further supported by the fact that most Call of Duty games can be controlled using a variety of input methods (Playstation controller, Xbox controller, mouse and keyboard). Call of Duty's design primarily focuses on being as captivating, entertaining, and immersive as possible. Nonetheless, the core gameplay of Call of Duty requires the player to perform certain actions over and over again. Despite not being experienced as work, this training inevitably makes the player better (faster, more accurate, etc.) at those actions. The goal of this newly proposed design strategy is to harvest this principle.

### 3.2.2 Step 2: Harvest this principle

Because of the fact that non-serious games can achieve serious goals as well, the distinction between serious games and their non-serious counterparts becomes blurred. Many researchers have tried to define the characteristics of serious games (e.g. [129, 203, 94, 176, 158]) and placed the emphasis on the importance of gameplay, feedback, human-computer interaction, challenge, scenario, fun, immersion, game design, and learning–game integration [93]. Micheal and Chen [163] define a serious game as "a game in which education (in its various forms) is the primary goal, rather than entertainment", a definition supported by Girard et al. [93], who state: "For us, the only difference between an SG (Serious Game) and an VG (VideoGame) lies in their intended purpose: usefulness for the former, entertainment for the latter", and many other researchers (e.g. Moizer et al. [169]). I do not share this opinion, since regular videogames have proven to posses great serious potential as well. My opinion more closely resembles that of Marsh [158], who argued that a regular videogame used for a useful objective can also be considered to be a serious game.

So, continuing with the previous example, Call of Duty is a videogame primarily focused on entertaining the players. But if it is used with the specific intention of enhancing hand-eye coordination, it can be considered a serious game, since it is effective at achieving an useful goal besides entertainment. So, I do agree with Girard et al. [93] when they say that "SGs are VGs with a useful purpose", but I do not agree that this purpose has to be carefully built into the game by developers; it can arise naturally from the game itself.

This is what this new design strategy aims to do: Create a game that is primarily fun, but the core gameplay of this game requires certain actions to be performed frequently and with specific form and timing, consequently training the player in those actions. The same thing that happens with essentially all videogames, the primary difference being that this strategy allows developers to guide this side effect to be something they want - like performing repetitive physical exercises. They can set a goal and deliberately steer players towards it, whilst maintaining the appearance that this is merely a side effect of the gameplay, which can be developed to be primarily fun. Rather than developing regular, non-serious games and hoping that the unintended serious side effect matches the desired goals and use cases, this strategy (theoretically) allows developers to influence this side effect without compromising the fun of the game.

Because this design strategy aims to design games that are primarily fun, but have a sneaky serious side effect on the player, we have decided to name it a design strategy for 'Sneakily Purposeful Games'.

In order to achieve this effect, without compromising the fun / entertainment value of the game, some concessions have to be made. The most important ones are already mentioned in Section 3.1. These, as well as other limitations / challenges this strategy imposes on the developers are described in detail in Sections 3.2.3 and 3.3.2.

### 3.2.3 Step 3: Define open-ended input types

In order for games to be able to take inputs from exercises performed, we need to somehow be able to translate a given exercise into a signal that the game can understand. However, it's not necessary to specifically design for certain exercises. Instead, it's sufficient to simply see what different types of inputs or input patterns are even possible, and simplify from there.

Although there is great variety in modern game input devices (e.g. motion control with Nintendo Wii or Kinect sensor, buttons that offer variable resistance on PS5, touchscreen), and game console designers have a long history of experimenting with novel input methods, most console games are still played using just a combination of thumbsticks and buttons [270, 201, 29, 151]. More exotic input methods are often reserved for specific use cases (e.g. using tilt to steer a car on a mobile game), perhaps due to poor accuracy [151]. Given this information, and given the fact that I intend to design a (case study) game fit for a wide array of use cases, I will limit my game to these inputs as well.

However, there are still many different methods of interpreting the same input. While a button may only communicate a '1' or a '0', games can be programmed to accept button presses, button releases, holding buttons down, combinations of buttons, repeated presses, etc. Certain exercises can easily be translated to provide a similar input (e.g. squeezing a ball longer to jump higher like in Hollow Knight or Mario).

Then, there are analog sticks, which return a value from -1 to 1 on both the X and Y axis. A mouse returns a position on the screen, but can also be programmed to function similarly to analog sticks. These inputs are often used to control movement and / or look around. Once again, these inputs can be translated into certain exercises (e.g. moving a limb in a certain direction can be interpreted similarly to moving an analog stick in a certain direction).

The abovementioned examples highlight the distinction between the physical action a player takes (e.g. pushing a button, squeezing a ball), and the in-game event that these actions trigger (e.g. jump, attack). Tang et al. [239] named these couplings as “Event Triggers”; they are events that trigger a transition between game sections / activations / events. Tang et al. [239] proceeded to categorize these triggers as Input triggers (based on controller input), time triggers (countdown / time-based in-game events), proximity triggers (collisions between objects, proximity between objects), and game mechanics triggers (how game objects behave based on what is happening in the game).

Whilst this ontology serves as a good starting point, the authors do not go into depth about the segregation of the in-game events and their trigger types. The segregation done is only on the basis of what kind of event occurs, for example, a player avatar action, a game setting change, starting, pausing and ending games, etc. [187, 78].

In his phenomenological approach to understanding and presenting the semiotics of game controllers, Blomberg [31] suggests that the controller to game pair is connected intimately, while having distinct actions. The controller action (physical act of pushing buttons, moving analog sticks, etc.) represents an action in the game world. E.g. mechanical (in-game) actions like shooting correspond to a specific controller action. He suggests that controller action or a combination of controller actions can fulfill a multitude of actions in the game world. Depending on how the controller is configured, it can both constrain and enable how a game is played.

Building upon this, Fernandes [78] came up with a paradigm that forms a link between controller action and game action. By establishing the distinction between controller action and game action, he believed that game actions can be designed on the basis of the available input devices and their ‘type’ of input provided to the game. Fernandes [78] referred to the coupling between external physical actions and the in-game actions they triggered as ‘Game Action Control Event’ (GACE), and stated that, for any game, there are 2 main GACEs:

- **Single Action:** Events that trigger an in-game action with a single controller action (e.g. button push, screen swipe), for example: Shooting a sniper in Team Fortress 2, jumping in older Mario games.
- **Continuous Action:** Events that require continuous action from the player, for example: Player movement in various games, mouse pointer action, Kinect motion control.

Any game action can be defined as either a Single Action, a Continuous Action, or a combination of the two [78]. Additionally, these actions can be standalone, or require directional- and / or amplitude control. Directional control examples include aiming, turning, etc. while Amplitude control includes controlling shooting power, jump height, etc. [78]. Any game action can be placed in one or multiple empty cells in Table 1.

| GACE | Standalone | Directional Control | Amplitude Control |
|---|---|---|---|
| Single Action | | | |
| Continuous Action | | | |

Table 1: Categorization of GACE types. Any game action can be placed in any (or multiple) empty cells

This distinction between controller actions and in-game actions is important, as is the mapping between them. Separating the controller actions from the in-game actions allows developers to think about the in-game actions not as a direct result following the controller action, but as a result following a certain type of input signal, which can be generated using a variety of controller actions (e.g. physical exercises). Using different GACE mappings, a wide range of exercises can be used as controller actions. This mental separation between controller actions and in-game actions is more prevalent among inexperienced gamers, as more experienced gamers are generally very familiar with the phenomenal connection between input devices, interface elements, and game objects [91]. However, in this case, the separation between controller actions and in-game actions is made by the developer, and not the gamers themselves.

When designing a game using this strategy, it is important to define a few core gameplay actions, and map them to different input types. For example: say a game has 3 core actions (jumping, attacking, and moving), it could be mapped such that jumping is linked to holding a button down (longer hold means longer jump), attacking is linked to a binary button (a '1' or a '0'), and moving is linked to analog input (e.g. stick down is crouching). Given this setup, the game can be linked to a large number of exercises, because it can receive a variety of different input types. This specific mapping of inputs is just an example, but ensuring that the game can receive a variety of different types of input is a key requirement for this design strategy, as it determines the type of exercises that can be used as inputs for the game later on. It is also the only way in which the serious aspect of the game directly imposes limitations that influence the gameplay on the developers.

#### 3.2.4 Step 4: Use placeholders

As explained in the previous paragraph, certain exercises can imitate certain input signals like button presses or moving an analog stick. But this mapping goes both ways, and games designed using this strategy can also be played without the use of physical exercises, by simply using a mouse and keyboard (or controller) instead. This is very important for 2 reasons:

First, it means that the game can be played as just a game. Players can play it without the intention of training / improving at a certain exercise. This broadens the potential playerbase of the game by including players who aren't playing the game for rehabilitation purposes. It also allows developers to experiment / playtest and assess the fun of the game without the influence of an intended secondary serious effect on the player.

Secondly, throughout the development of a game, the character can be controlled using the mouse and keyboard (or controller). Not only does this make testing much easier, but it also prevents the developers from thinking too much about the serious use cases for the game. This avoids a common issue in serious game development: the serious aspect influencing gameplay too much.

If a developer knows a specific exercise will be linked to the game, this developer will, either consciously or unconsciously, attempt to tailor the game for this specific use case, potentially at the cost of its entertainment value. Because the use cases are intentionally left undefined, the implementation is very open-ended. Any exercise that can be translated into a certain input signal could theoretically be used as an input for the game. Not designing specifically for certain use cases does have some downsides though, which are discussed in Section 3.3.2.

### 3.2.5 Step 5: Implementing the serious elements

After the game has been developed, it is time to start thinking about the serious applications again. Ideally, the separation between the serious aspects and the rest of the game has prevented the developers from letting the serious aspects influence gameplay-related design decisions at the cost of the entertainment value of the game. However, now it is finally time for the serious aspect to be fully implemented into the game.

For the most part, this step is beyond the scope of this design strategy. The strategy aims to ensure that games are suited for the widest range of different exercises (using methods described in Sections 3.2.3 and 5.4), but intentionally doesn't get into more detail than that. The design strategy does not necessarily have to concern itself with the types of sensors used to translate specific exercises and movements into input signals. Rather, the strategy just assumes it is possible to do this. This task is made as easy as it can be, since the game should be designed in such a way that it is able to accept a wide variety of input signals. Potentially, physical therapists can even tune the level generation algorithm to create levels that incite the players to perform specific actions at specific times, frequency, or with a specific quantity.

Despite this step being out of the developers' hands for the most part, it is important to think about it, especially towards the end of the development process. Developers should ensure that this task is as easy as it can be, since it does pose an additional barrier to play. This challenge is described in more detail in Section 3.3.2.

## 3.3 Strengths & weaknesses

Like with any other design strategy, this one comes with its own set of strengths and weaknesses, which are discussed in this section and summarized in Table 2. Note that this strategy remains untested for now, so the strengths and weaknesses listed below are just hypothetical; it's just what I would personally expect to happen. The rationale behind these expectations is also explained. Also note that the expected disadvantages to the usage of this design strategy tend to originate from the same principles that the advantages are meant to originate from, meaning it is very difficult to change the aspects that cause problems without reducing the upsides as well.

These strengths and weaknesses are important, as they form the basis for the evaluation criteria for the subjective evaluation of the process of developing a case study game (described in Section 4.1). I will evaluate to what extent the strengths actually translated into good elements of the game, how much the weaknesses actually hampered the development process and what creative solutions I employed to circumvent them, and add any newly discovered strengths or weaknesses to this list.

### 3.3.1 Strengths

The primary intended advantage is that games designed using this strategy should theoretically retain their fun and entertainment value, which is one of the most important characteristics of any game [129]. If a game is fun, it's also intrinsically motivating [129, 58, 72, 165, 265]. Intrinsic motivation is the thing that makes an activity fun or rewarding for its own sake, rather than for the sake of some external reward [143, 155][NS40]. Proper, enjoyable, fundamental gameplay is required to create an intrinsically motivating game; "a very good game context (story, aesthetics, etc.) cannot sustain motivation if gameplay activities are ill-designed" [74].

The entire goal of this design strategy is to create a game that has this quality, and is also capable of serving some serious purpose (e.g. physical rehabilitation). The separation between gameplay design and the serious element, as well as intentionally not defining the implementation of the serious element, is meant to prevent it from influencing gameplay-related design decisions and potentially reducing the entertainment value of the game.

A second advantage is that games designed following this strategy, or at least the case study game as I intend to make it, will be broadly applicable. While serious games are applied in a broad spectrum of application areas, most of them tend to be designed for very specific use cases (e.g. the games for upper limb stroke rehabilitation discussed by Burke et al. [38]) [234, 32, 204]. Games designed using this strategy can interpret any exercise that can be translated into certain signal types.

This also means that the games created using this strategy can be played just for fun, without any intended secondary effect. Players can play this game using just a controller, or mouse and keyboard, and may not even be aware of its serious applications. This broadens the potential playerbase of such games, and enhances their commercial viability.

Since this strategy allows for a wide range of controller actions to serve as inputs, the GACE mapping could be configured such that the controller actions resemble the in-game actions (e.g. extent leg to jump, extent arm to punch, etc.). A study by Nacke et. al. [179] explored the use of direct and indirect physiological control to enhance game interactions. Although their study did not focus on the types of real-world input actions used to perform in-game actions, it did provide encouraging results that favour the use of direct physiological control inputs like breaths in terms of immersiveness and novelty, and they suggest that having a natural relationship between the player real-world action and the in-game action (e.g. actually extending an arm to perform an in-game punch) is among the most likeable aspects of using physiological inputs [179, 78].

Because this design strategy is based on mimicking traditional game design methods as closely as possible, rather than following design strategies specific to serious games, it may be easier to adopt for game developers unfamiliar with developing serious games. The barrier to switch from regular game design to serious game design is lower if the design strategies required for serious game design more closely resemble the strategies developers are already familiar with.

The fifth advantage to using this strategy is not unique to this particular strategy, but rather applies to any newly proposed design strategy: it might prove effective. The need for new design strategies for (serious) games is already touched upon in Section 1, but this section does not mention what a new design strategy could potentially achieve.

Should this new design strategy prove to be capable of achieving the above-mentioned goals, it could get adopted by others and used to design more games. It will be iterated and improved upon, maximizing the advantages it has, and finding clever ways to negate or avoid the disadvantages. It will become another tool that game designers can use to more efficiently create better (serious) games.

These advantages can be translated into other, more case-specific advantages. For example: Creating a single game that can be used for different rehabilitation programs as opposed to creating an unique game for each program can result in reduced development costs overall, which can, in turn, translate into higher development budgets for the game, that can be spent on improving the gameplay. A broader playerbase and potential commercial viability can have the same effect, since developers can utilize a larger budget if they expect to make more profit from sales.

### 3.3.2 Weaknesses

One of the most vital and unique aspects of this new design strategy is intentionally not defining the game's serious aspect and its implementation until later in the development stage. This is done with the intention of preventing it from influencing gameplay-related decisions and hampering the fun of the game, but it may also cause the game to be designed in a way that makes it difficult to actually implement the serious aspect. E.g. if your gameplay-related decisions guide you to create a fast-paced endless runner, it may prove difficult to turn that into a serious game for meditation / relaxation. There are some measures designers can take to increase the ease of implementation (e.g. procedural level generation that can adjust levels based on the intended frequency of a player's inputs, having open-ended input types that can be mapped to a wide array of exercises for the core mechanics), but there are 2 problems with this.

Actually, there is just one fundamental issue to this strategy, but it can express itself in 2 ways. The first way is that the developers do not take enough measures to ensure smooth implementation of the serious element, and compromises have to be made later in the project to ensure that the game and the serious element can still be matched together. The second way is the opposite; developers take too many measures to ensure the serious aspect can be implemented. At best, this is just unnecessary extra work for the developers, and at worst it may have a negative impact on the design of the game and hamper creativity. The designers essentially have to make an (educated) guess as to what measures they should take to ensure the serious aspect can be implemented, and they can potentially guess incorrectly.

Another potential downside to this design strategy is that, since the serious aspect of the game depends almost entirely on the player's input, and the player's input may differ significantly per use case (e.g. one player may control the game using breathing, whilst another may decide to control the game using hand movement), it is nearly impossible to design with a (set of) specific input device(s) in mind. This may seem like a small sacrifice, but the input device plays a critical role in shaping a player's experience and immersion within a game [270, 201, 35]. McGregor et al. [160] states that play does not exist in isolation from its surroundings, and the game space must be interpreted according to how it affects gameplay. When we play videogames we play both in real space and in a construct of space [160]. Espen Aarseth [1], Henry Jenkins [123], and Bernadette Flynn [80] all posit spatiality as an essential part of videogames, crucial to understanding them. This (spatial) context includes the type of controller that is used to interact with the game.

Bianchi-Berthouze et al. [26] demonstrated that the controller itself plays a critical role in creating a more complete experience for the gamer. Pasch et al. [189] states that games that are designed to foster movement, rather than typical game behaviour, require both the controller, as well as the interface of the game, to be designed to require specific movements and to give proper feedback about the movement being performed. Björk et al. [29] illustrates the importance of input methods by highlighting how the game industry is constantly looking for new methods to make full use of new (gaming) platforms, like mobile phones and PDAs. Möller et al. [170] supports this notion, stating how game providers try to improve their users' experience by, among other things, developing new interaction techniques. Breuer et al. [32] even hypothesized that technology-driven innovations in the game industry (e.g. a new type of input device) could lead to entirely new videogame genres. Brown and Cairns [35] claimed that invisibility of controls (and by proxy the input device) is required for total immersion to take place.

There is also the practicality aspect that comes with certain controllers. If, for example, a certain player has to squeeze a ball to train their hands because they suffer from rheumatism, one hand is entirely dedicated to just one input. But the game requires the player to perform multiple inputs (jumping, walking, attacking, etc.). Will this player be able to control all other inputs with their other hand? Most likely not. Given how this game is best suited for serious implementations like physical rehabilitation, it's probably fair to assume most players will have some conditions that can make playing the game more difficult for them, especially when the additional challenge of controlling the character using non-traditional input methods such as squeezing a ball is added. Some additional (accessibility) options are needed to solve this problem (e.g. keeping the control scheme minimal, or implementing an AI that can perform certain tasks autonomously: the character moves automatically and the player only has to control the jump). Accessibility considerations are discussed in more detail in Section 5.2.

Then, there is the issue that not every exercise is the same. Some players may want to control the game by squeezing a ball, whilst others may want to extend their legs, for example. These different exercises can both be used to control the same action in the game, let's say the jump. However, they require different levels of energy, skill, coordination, and timing. This can make it difficult to give the game a proper difficulty level and learning curve. It's incredibly important for the pacing of the game as well. If the goal is to create a fast-paced game with, e.g. double jumps, one player might just have to squeeze twice, whilst another player must extend their legs, retract them, and extend them again, in a very short period of time. Since both players are playing the same game, it is very difficult to design a game that feels fair for both of them. This problem is even more complex for input methods that aren't even entirely controllable by the player, such as breathing or blinking, although this mechanic itself can also be applied creatively (e.g. Before Your Eyes).

Different use cases in terms of input methods also mean that different players need to use different hardware to interact with the game. One player may need a sensor to measure the force with which they squeeze, whilst another might need a sensor to measure the angle of their arm. This problem is largely out of the scope of this project, but there are certain ways to design the game such that it is flexible and open to creative solutions. For example, developers might decide to design the game to be able to take Serial inputs from an Arduino, allowing the users to design their own hardware. This, however, does require a much higher investment from the user in terms of costs, time, and effort than other videogames do. It should be noted that this problem is not unique to this design strategy, however. Different motor-based serious games have always required different sensors and unique controllers have long been a staple of peripheral-based games like Guitar Hero. The main difference is that this strategy aims to make a single game that can take different inputs, rather than a completely new game for each use case.

Different forms of input may also pose challenges with regard to (procedural) level generation. Most videogame levels are designed around their core mechanics, and the pace and frequency with which these actions are intended to be performed. As mentioned already, this pace and frequency may differ significantly for different users who use different input methods. This problem is especially significant for videogames that use procedural level generation, since a common approach to procedural generation is rhythm-based generation, where input patterns are transformed in a valid geometry [175]. This is very difficult to do when there is a high variety in input patterns.

A potential solution to this problem is to use chunk-based generation instead, where samples are humanly created and automatically assembled like a puzzle [175]. The benefits and challenges to the usage of procedural level generation, as well as an explanation of the inner workings of the level generation algorithm in the case study game, can be found in Section 6.7.

Lastly, the design strategy is only well-suited for the design of certain serious games; the motor-based serious games (as discussed in Section 2.2). It isn't really fair to call this a weakness of this strategy, since the strategy itself was never intended to be a one-size-fits-all type of solution. Nonetheless, there are still numerous potential use cases for the games that this strategy is capable of creating. This design strategy is well-suited to facilitate serious goals like exercise, physical rehabilitation, and relaxation, but not education, which remains the area that most serious games tend to target [32, 166].

| Strengths | Weaknesses |
|---|---|
| • Preserves fun elements which leads to intrinsic motivation within the players.<br>• The same game can be used to aid different exercises and recovery programs.<br>• Games developed using this strategy can serve as regular, commercial games as well. Broader playerbase, enhanced commercial viability potentially resulting in higher budgets and better exposure.<br>• Controller actions could potentially resemble in-game actions more, leading to higher levels of immersion and fun.<br>• Lowers barrier for serious game design.<br>• Additional tool for game designers to apply to future projects. | • Not defining the serious element may hinder implementation later in the project, or result in unnecessary extra work earlier on.<br>• Unable to take input device into account when designing the game.<br>  – Unable to take the influence that the input device has on things like motivation and enjoyment into account when designing the game.<br>  – Practicality aspect: Additional work and / or costs are required to be able to play the game. Higher entry barrier compared to other games.<br>  – Rhythm and timing: Not all exercises can be performed with the same frequency and / or accuracy. This influences a lot of gameplay-related elements such as the level design (and therefore also procedural generation), learning curve, skill floor- and ceiling, and pacing of the game.<br>• Strategy not suited for design of certain types of games (e.g. educational games). |

Table 2: Expected strengths and weaknesses of the 'Sneakily Purposeful Games' design strategy

# 4 Creating a game

As mentioned earlier, I will continue this project by developing a serious game following this strategy. My hope is that the development of this game will familiarize me with the strengths and weaknesses of this design strategy, and that the game can be used as a case study to determine its viability as a design strategy for fun games that serve serious purposes.

While this design strategy allows for the creation of a variety of games, it is my intention to create a game that properly represents the design strategy; a typical example of a game developed using this strategy. I therefore hope to encounter most of the unique up- and downsides to the usage of this strategy and form a realistic picture regarding its viability. Although I will not be able to scientifically prove the effectiveness of this strategy using just a case study, it does allow me to reflect on the strengths and weaknesses of the strategy, or possibly discover additional constraints or requirements for making the strategy viable / effective.

## 4.1 Research questions

Fundamentally, this report aims to address an existing problem: the poor quality of serious games due to the limited fun and entertainment value they provide, as described in Section 1. It does so by proposing a new tool that I hypothesize will work well; the design strategy described in Section 3. Since the design strategy isn't yet proven to be effective, the primary question of this report becomes:

- "To what extent is the 'Sneakily Purposeful Games' design strategy capable of creating games that are both fun and capable of serving serious purposes?"

However, it is very difficult to answer this question directly. An intuitive approach for evaluating a design strategy would be to look at the quality of the games it is able to produce, and the efficiency with which it can produce them.

Given that this is a completely new approach to serious game design, there aren't any games developed following this strategy yet. Developing a videogame takes a lot of time and resources [245, 244, 268], and the number of games required to achieve statistical significance when evaluating would take up too much time and resources, and is therefore beyond the scope of this report.

Even if there were enough games to evaluate, they are different games, fit into different genres, are created by different designers and developers, deviate from the strategy in different ways, are targeted at different demographics, etc. There is no single definition for a "Good game"; what one player might consider a good game might be considered a poor game by another player.

Malone [155] categorized the characteristics required for a "Good game" into challenge, fantasy, and curiosity. Prensky [197] listed fun as one of the most important characteristics of good games, and listed good gameplay as one of the foremost characteristics of good games a year later [198]. However, all these characteristics are still subjective and prone to personal differences. The high number of variables and potential biases, combined with the low number of potential games to test with, make objective scientific evaluation of the design strategy near impossible.

However, as Malone [155] states: "It is not at all unusual in the history of science for practice to precede theory". My approach to evaluating the proposed design strategy will be to develop a game and use it as a case study. If the game is sufficiently fun and capable of serving a serious purpose, it gives an indication regarding the viability of the design strategy itself. But the process of developing this game will hopefully also provide me with insights into the strengths and weaknesses of the strategy, which aspects of this strategy I feel translated into good or bad things within the game, and what tips I would give to other developers that intend to use this strategy in the future.

The review of the design strategy will therefore be subjective, based on a single measure (the case study game), and my experiences. Regardless of the quality of the case study game, this study will not be able to objectively prove the viability of the proposed design strategy.

This inherent subjectivity is aligned with this study's goals though, since the aim of this report is not to prove this design strategy as a fixed formula for creating fun serious games, but to show whether or not it has potential, and inspire other developers to adapt it. Ideally, this strategy becomes another tool that game developers can use to create better games, and, by adapting it, they will also help to further develop and refine the design strategy by finding creative solutions to negate its weaknesses and applying it in new and creative ways. This expansion of the developer's toolset is the core value of my research.

The primary goal of this design strategy is to create fun games, which are also capable of serving some serious purpose; physical rehabilitation in this case. The case study game will be evaluated based on these criteria. Complementary to this, I will also give a subjective review of my experience with the design strategy and advice I have for any game developers that intend to employ it in the future. The questions I will answer for this evaluation are:

- How fun is the case study game?[3]
- To what extent is the case study game capable of serving a serious purpose (physical rehabilitation)?[4]
- Tips for future usage - What aspects of the design strategy translated into what characteristics of the game? (subjective). What limitations did

[3] 'Fun' is a subjective characteristic. The exact definition and methods employed to evaluate it are described in Section 7.1

[4] There is evidence that states that simply performing the exercises for physical rehabilitation is sufficient, since a lack of motivation is the primary issue [204, 38]. The primary question here is to see whether it is technologically feasible, what the range of applications is (e.g. what different exercises can realistically be used as inputs for this game), and to what extent it influences the fun / entertainment value of the game.

the design strategy impose on me and how did I deal with those? What aspects were not worth the effort?

My hope is that the combined answers to these questions will give a proper impression regarding the viability of the design strategy. But the case study game needs to be developed first - a process that is described in Sections 5 and 6.

# 5 Requirements

This chapter explains some key requirements for the case study game. Although there is some overlap, these requirements differ from the design decisions described in Section 6 in the sense that these are the key goals I aim to achieve with the case study game, and the design decisions discussed in Section 6 are choices made in order to achieve these goals. For example: Accessibility is a requirement for my game (explained in Section 5.2), but the decision whether to make a 3D puzzle platformer or a top-down shooter is a design decision; both games can still be accessible. Many of these goals cannot be achieved by a single design decision, but rather come from a combination of small design choices, which accumulate into a certain characteristic of the game (e.g. fun, replayable).

Naturally, there are more requirements that the case study game has to adhere to than the ones listed in this chapter. Things like being lightweight and having proper performance (if a game requires expensive hardware, a significant part of its potential playerbase is excluded. Accessibility / availability terminology is explained in Section 5.2), not containing excessive gore or scary / offensive imagery that might deter some players, etc. These requirements are not discussed in detail because serious games designed using conventional strategies should generally also adhere to these, and because they do not significantly influence gameplay-related design decisions.

## 5.1 Fun and intrinsic motivation

The primary requirement for the case study game is that it is fun, and by extension, intrinsically motivating [129, 58, 72, 165, 265]. Fun is one of the most important characteristics of any good game [197]. The ability to create an equally fun gaming experience as regular, non-serious games is intended to be the primary advantage to the usage of the proposed design strategy. The importance of fun and intrinsic motivation has already been touched upon in Section 3.3.1.

There is no single, fixed way to create a fun game, however. Fun is not a universal truth shared amongst all players, but rather a personal experience that may differ between players. As such, my philosophy will be that, rather than compromise in order to try and please everyone, my game should offer an unique experience that greatly appeals to some players. Trying to please everyone generally means pleasing no one [NS8]. Although this uncompromising philosophy may initially reduce the player base, it'll typically heighten the enjoyment of those to who the game does appeal [NS8]. An example of this philosophy put into practice can be seen in Section 6.8.

One other note regarding fun is that, in my opinion, in order to provide a fun gaming experience, every single aspect of a game should be sufficiently well-designed, with some standing out. Those elements that stand out will mostly determine the overall impression that players have of a game (e.g. Snappy combat, exploration, and atmosphere in Hollow Knight). However, if a single element of a game is inadequate, it can ruin the entire experience (e.g. Cyberpunk 2077 is a great game overall, but was initially plagued with glitches and bugs, resulting in negative reviews). Another example is given by Fabricatore [74], who stated that "A very good game context (story, aesthetics, etc.) can not sustain motivation if the gameplay activities are ill-designed". So although different elements of the game will naturally differ in quality, I should take care that no single aspect of the game is so incommensurate in terms of quality that it ruins the entire experience.

Lastly, it's important to note one important assumption regarding the fun of the case study game. The rationale behind the design strategy is that, if the design process for serious games resembles the way that regular, non-serious videogames are designed as closely as possible, the resulting product will offer a similarly fun gaming experience. However, this does mean that, if I, as the developer of this case study game, am unable to create a fun, non-serious game, the (serious) case study game won't be fun either. This, as well as other, similar assumptions, are discussed in Section 9.

## 5.2 Accessibility

Videogames are more popular than ever, especially amongst children and adolescents [99, 23, 93, 269]. However, despite the increased level of interest in games, a large group of people find themselves excluded from playing videogames because of a disability [11, 27, 91, 96][NS57]. Although their needs are often overlooked, an estimated 20% of casual gamers experience difficulties playing videogames due to disabilities [84]. Videogames should actively balance such drawbacks to even the chances to win [110], and ensure most players have a similar experience; the experience that the designers intended. There are various legal, financial, and ethical reasons for wanting games that are more accessible to this demographic, and as the popularity of games increases, making games accessible will only become more important [27].

However, as Torrete et al. [244] points out: "the creation of accessible technologies has focused unequally on different fields of software development. While the accessibility of websites is reasonably covered, other areas such as interactive multimedia (and especially videogames) are still trying to find the most suitable way to create accessible products". Nonetheless, newer titles have paid more attention to include options that players can use to negate or reduce some of the difficulties posed by their condition(s). Technological improvements, research, creative solutions used in the past, and positive feedback from disabled players have all contributed towards more accessible games.

However, since serious games / game-based learning is still an emerging field, developers are still more concerned with creating more appropriate games for learning, rather than with making them more accessible, assuming that accessibility could be eventually addressed in the future [244]. Implementation of accessibility enhancing features also comes at a cost, putting additional strain on the often already tight development budgets of serious games [244, 172]. Still, features like remappable controls, colorblind filters, subtitles, and difficulty modes have become more common [27]. The trend seems to be that a small amount of work can often make a great difference [NS55, NS57].

When talking about 'accessibility', this report refers to the inclusion of such options, not whether or not a certain person or demographic has (easy) access to the game (e.g. age restrictions, availability in certain countries, console exclusive launches, or financial accessibility), which is referred to as a game's 'availability' [NS65]. While the availability of (serious) games is an interesting topic in and of itself, it is beyond the scope of this report.

While accessibility options are important for every game, I'm of the opinion that they're especially relevant for the case study game specifically. Since the intent is to make a game that supports physical rehabilitation, it's probably fair to assume a relatively large portion of the players may have certain conditions that can make playing the game more difficult. Even if their impairment / disability isn't related to the physical therapy, it's unfortunate if players are unable to play the game solely due to a lack of accessibility options.

Designing for disabilities and enhancing accessibility is a complex, emotional, and highly personal topic. Different solutions work for different people and different types of games. The general philosophy regarding this topic, and the one that I will adapt for the design of the case study game, is that a higher degree of customisation will result in enhanced accessibility overall; the more options a game provides to its players, the greater their ability to customize the game in such a way that it best negates the challenges posed on them by their disability [NS65, NS56]. Since the case study game will exclusively feature single-player modes, there is no need to worry about problems such as accessibility options providing an unintended competitive advantage to players who do not need them, which can result in an unbalanced game [132].

Creating accessible software (and videogames) has become a popular topic of research recently, with related papers published in international conferences (e.g. [12, 27, 97, 98])[5], and a handful of articles appeared on gamasutra.com[6] (e.g. [NS2, NS23, NS31]), which is the most visited and referenced web site for the videogame industry and professionals [96].

This has led to a lot of sources that index and summarize techniques used to enhance the accessibility of games or other software applications, as well as the ways they can or should ideally be implemented, the most important of which are discussed below. Given the abundance of available literature on this topic, this report will not go into great detail about why certain techniques can help negate the negative effects posed by disabilities, nor will it attempt to develop

[5] Much more has been published since these. These are just some early examples

[6] Gamasutra changed its name on August 26th 2021, and is now called gamedeveloper.com

new techniques.

The Web Content Accessibility Guidelines (WCAG) [41] is a set of guidelines that aims to provide guidance on how to create web content that accommodates users with different types of impairments [269]. Although there is significant overlap with other sources, it should be noted that these guidelines are not created specifically for videogames. This may be of influence on their effectiveness when implemented in videogames, since videogames are fundamentally different from other software [269].

Yuan et al. [269] mentions 2 attempts at composing a set of guidelines similar to the WCAG [41], but specifically for videogames. The first being the Independent Game Developers Association (IGDA) Special Interest Group (SIG) on Game Accessibility [114], which published a white paper [28] in 2004 that proposes 19 accessibility guidelines derived from a survey of 20 accessible games. The second comes from the Norwegian organization 'MediaLT', which published a set of 34 accessibility guidelines specifically for videogames [NS43][243][7], based on the previously mentioned IGDA-SIG guidelines, as well as their own set.

Lastly, this report takes great inspiration from a number of videos on the subject. Mark Brown, from the YouTube channel 'Game Maker's Toolkit', has an insightful video series called "Designing for Disability" [NS62], in which he discusses the unintended challenges certain games can pose for people with certain disabilities and the techniques games can implement to reduce this effect [NS55, NS57, NS56, NS59].

However, over the past decades, the HCI community has realized that guidelines, when used in their original form, are quite ineffective and unusable in the hands of most practitioners [96]. Although several reasons can be mentioned (e.g. [213, 242]), the fundamental problem is that (accessibility) guidelines, such as the ones listed in the abovementioned sources, typically come in an abstract, context-independent form which tends to make them ambiguous or too abstract to be applied in a specific context [108]. (Accessibility) guidelines often assume absolute validity, when in practice they are only applicable in specific contexts [81, 251]. Furthermore, guidelines are often conflicting or, on certain occasions, may create new problems while solving another [96]. Factored together, these problems result in guidelines often being ignored or not well understood, and therefore, not appropriately used [96].

Throughout the development process, I should take care to only implement solutions that are suitable to the context of the game and the situation the player is currently in. Due to the large number of potential accessibility-enhancing features, combined with the limited available development time, my intention is to focus primarily on small, simple, easy-to-implement tools and techniques

[7] The webpage is inaccessible at times, so a secondary source in which the guidelines are discussed is also added

that can still make a big difference for a lot of players, rather than developing complex systems that will only be useful for a very small percentage of the playerbase.

In order to determine which accessibility features are effective aids for which disabilities / impairments, some classification is needed. This report follows the classification of impairments / disabilities as defined by the World Health Organization's (WHO) manual: International Classification of Impairments, Disabilities, and Handicaps (ICIDH) [185]. This classification is in accordance with the writing guidelines for technology and people with disabilities [43], a parlance to which this report also aims to adhere. This method classifies disabilities / impairments into 4 categories; vision, auditory, motor, and cognitive. Notably, this same method of categorisation is used in most sources (e.g. [269, 27, 54, 28][NS2, NS62]).

Different classification methods do exist, such as the further classification into subclasses as discussed in [185], or the classification used on gameaccessibilityguidelines.com [NS25], which also includes a "General" and a "Speech" category, and conveniently classifies the techniques developers can use to enhance accessibility for each category as either "Basic", "Intermediate", or "Advanced", depending on the effort required to implement them.

However, for the current use case, categorizing impairments / disabilities into 4 basic categories is sufficient. A short description of each category, examples of conditions, impairments, or disabilities that fall into that category, and some techniques game designers use to alleviate these issues can all be found below.

- Vision impairments / disabilities include (color) blindness and poor eyesight. Designers can help negate the challenges posed by such conditions by including things such as: colorblind filters, properly sized fonts, proper contrast, support for screen readers, or even a "sound compass" (a tool that allows the game to be played almost entirely via sound. Terraformers (2003), a first-person adventure game designed for the visually impaired from the very start, first introduced this tool and was the winner of the "Innovation in Audio" award at the Independent Games Festival in 2003 [27]) to reduce these issues.

- Auditory impairments / disabilities include (partial) deafness or an inability to triangulate sound or distinguish characters by voice. The primary way that the negative effects of Auditory impairments / disabilities are negated is by the use of subtitles [NS57]. One of the simplest methods that developers can employ is to ensure that all important information is communicated across multiple channels (e.g. visually and via sound), so that players can choose which channel(s) to rely on [244][NS65]. Fortnite mobile is a good example of this, where critical sound effects like gunshots are displayed in a ring around your character, indicating what sound the player is hearing, as well as the direction from which it came, all in one go [NS57].

- Motor impairments / disabilities include arthritis, paralysis, cerebral palsy, repetitive strain injury, and more [269]. Difficulties in speech control can also be considered a motor impairment under this categorization. These challenges are often approached by giving the player the ability to remap controls or adjustments to the required inputs (e.g. not having to smash a button for a quick-time event, or toggling from a hip-fire stance to an aim-down-sights stance by pressing a button instead of having to hold it down).

- Cognitive impairments / disabilities include things like epilepsy, dyslexia, learning disabilities, or a predisposition for VR-induced motion sickness [NS59]. Due to the large variety of cognitive impairments / disabilities and the different ways they can express themselves, there are no techniques that work for every condition. However, there are common features that are known to be helpful in this regard. E.g. difficulty modes, tutorials, epilepsy warnings, ensuring the game can be paused, tooltips that can remind players how certain items can be used, or a journal in which players can see their current objective.

Naturally, there exist more impairments / disabilities than those mentioned above. There are also conditions that can fall into multiple categories, e.g. lack of fine motor control due to down syndrome (motor / cognitive). There are also solutions that can aid with conditions of different categories, or can even help players without impairments / disabilities. Subtitles can be a useful tool for people with auditory impairments / disabilities, but can also help reduce the cognitive load of having to decipher what the characters are saying (auditory / cognitive). Subtitles are also a great example of an accessibility option that benefits players without disabilities / impairments as well; Ubisoft states that around 60% of all Assassins Creed Origins players had subtitles turned on while playing their title [NS24]; a far larger percentage than just the players with hearing impairments.

Lastly, it is important to note that not all impairments / disabilities affect a player's gaming experience to the same extent [269]. It is important to distinguish the different types of barriers individuals with disabilities face when trying to play computer games [269]. This report adopts the definition by Yuan et al. [269], who distinguishes two different types of barriers: Critical and Non-critical.

- Critical barriers completely prevent certain players from playing a game. For example: it is essentially impossible for a blind person to play Call of Duty: Warzone.

- Non-critical barriers mean that the game is still playable, but the player will have a reduced experience as a result of their condition. For example: Colorblind players can still play Firewatch, but will have a reduced experience since the game heavily relies on its atmosphere and aesthetic and the colors used to create them.

Critical barriers are generally very hard to overcome completely, but can sometimes be transformed into non-critical barriers (e.g. AbleGamers collaborated with Microsoft to release the Xbox Adaptive Controller in 2018, which allowed (among others) amputees to play videogames, a task that was previously impossible for most of them [NS22]). Reducing non-critical barriers until they no longer pose a problem, or the problem they pose is reduced, is also important. Small features that take relatively little work to implement can often make a great difference here [NS55, NS57].

The purpose of this section is to explain why accessibility is important, especially for my game, and highlight some of the challenges this poses for development. The techniques used to enhance the accessibility of the case study game and their implementation are discussed in Section 6. Please note that the focus of this study is not to develop a product, but rather, the game is only developed as a means to evaluate the design strategy. As such, factors like accessibility, which would be of great importance in production, may receive less attention in this study, since their implementation is not required to achieve this goal.

## 5.3 Replayability

Replayability[8] is a major factor in the long-term enjoyment of a videogame [33], and a key requirement for the case study game. The game should remain enjoyable for longer periods of time, so that it is suitable to accommodate rehabilitation programs of different durations. This focus on replayability has had a notable influence on my game design decisions.

This section describes a few key decisions that were made relatively early on in the development process in order to preserve / enhance the replayability of the case study game. Naturally, replayability influenced more decisions than are described here, and these decisions are influenced by more factors than just replayability.

Starting with the core focus of the game. Games can focus on a lot of different parts; some games primarily focus on the gameplay (e.g. the Rayman series), whilst other games can primarily focus on narrative (e.g. Firewatch, The Stanley Parable), or heavily lean into the social aspect (e.g. Fibbage XL, Ultimate Chicken Horse, Pico Park), etc. Games almost always contain a combination of these areas, but there is usually a distinguishable primary focus.

Some of these areas of focus are better suited to create games with high replayability than others. In games with a heavy focus on narrative (e.g. Firewatch, Disco Elysium), the player is largely motivated by their curiosity to learn how the story unfolds. Subsequent playthroughs will be far less interesting to them since they will already know the ending. The same holds true for games

[8]'Replayability', in this context, refers to how fun it is to play the same game for longer periods of time, or to play the same level again after dying. Not how fun it is to finish the game and then play it again from the start.

with a heavy focus on humor: "A joke is only funny once, twice if you make it a callback" - William Pugh [NS13].

Games with a heavy focus on aesthetic / graphics[9] (e.g. GRIS, Journey) also typically have low replayability. Graphics alone cannot provide good gameplay [198]. Although the visual appeal of a game can help keep players concentrated and engaged [NS39], games that (almost) solely rely on being aesthetically pleasing / visually impressive can become less interesting over time since there is not much else to keep the player engaged.

Lastly, puzzle games also tend to have low replay value [NS68]. In good puzzle design, the challenge should come from the puzzle itself, not its execution [NS58], meaning that once the player has figured out the solution to a specific puzzle, it should be relatively easy to execute said solution. As such, replaying a puzzle is far less interesting since the player will already know the solution.

All of this is not to say that games that focus on these aspects are bad. For example: Portal is a puzzle game with a heavy focus on narrative / humor, and as such, generally isn't perceived as having much in terms of replayability [NS68]. Despite this, both the Portal games are widely considered to be great games and occupy prominent placements on IGN's Top 100 games of all time [NS33]. High replayability isn't a prerequisite for a good game, and, in my opinion, shouldn't be. Certain games are better suited to be experienced only once or twice, and the impressions they make in that short time are all the more valuable and impactful because of it. However, due to the intended application of my game as a tool for physical rehabilitation therapy programs of differing durations, a high level of replayability is desired. The primary focus of the case study game will be on moment-to-moment gameplay, especially in the form of combat and platforming. This focus is elaborated upon in Sections 6.2.1, 6.5, and 6.8.

Aside from avoiding the abovementioned aspects as core focuses, the design of the levels also plays a key role in enhancing the case study game's replayability. This high-replayability level design is implemented across 2 levels, which this report refers to as the 'micro level' (within a level or in-game area), and the 'macro level' (Across different playthroughs / different levels or in-game areas).

At a micro level, the videogame environment should accommodate multiple different playstyles. If there is only a single fixed solution to a certain problem or challenge, overcoming it can quickly become boring [245, 33][NS54, NS36]. An in-game challenge is more interesting to replay or reattempt when it allows for multiple different approaches (e.g. kill or avoid enemy) [245].

[9] Aesthetic and graphics are different: Aesthetic is the look the designer creates and graphics / graphical fidelity refers to how well this aesthetic is conveyed to the player. Simple graphics such as pixel art can still be great aesthetically (e.g. Hyper Light Drifter, Blasphemous, Enter The Gungeon)

Supporting multiple approaches to tackle in-game challenges is also a useful methods for allowing players to adjust the difficulty of the game by finding the approach that best suits their own skills [NS63]. For example, a player who is skilled in the combat of a game might decide to attack some enemies head-on, whilst a player who is better at platforming might try to go around them.

I personally find the Dishonored series to be extremely good at this. Every single level can be finished without killing a single enemy [NS45, NS46], and every single in-game encounter can be approached in numerous ways. Generally, if a player thinks "If I try this, would that work?", the answer will be "Yes". This high level of reactivity to the player's actions encourages players to try new, sometimes useless, things [245]. The Dishonored series uses this principle to provide players with an incredible amount of in-game freedom and agency without having the game be devoid of challenge.

Providing multiple methods of tackling a single challenge is an example of a single requirement (replayability) that influences multiple gameplay-related elements (replayability and difficulty / challenge). A similar phenomenon happened with Rogue. Brewer [33] pointed out how, in Rogue's case, the high level of randomization affected both the game's replay value, as well as its difficulty.

I intent to employ similar solutions to game design problems where a single adjustment influences 2 or more gameplay-related elements of the case study game, pushing both of them toward their desired state. This design philosophy follows that of Shigeru Miyamoto, who defined a good idea as "something that does not solve just one problem, but rather can solve multiple problems at once" [268].

At a macro level, the case study game will employ procedural generation to create its levels. Procedural generation has become a popular means to enhance a game's replay value [175, 33][NS4, NS64], and has been an important research topic for several years [225]. Procedural generation ensures that levels are different each time, and playing a 'new' level is much more interesting than replaying the same level again, even if all of the mechanics are the same [245].

There are multiple reasons for the choice to use procedurally generated levels. Firstly, because of the high replayability associated with procedural generation as described above. Secondly, procedural generation makes the levels less predictable and prevents the players from memorizing level layout / geometry [175], which shifts the player's main method of overcoming in-game challenges from memorization to mastery over the game's mechanics [NS50, NS64].

Lastly, there is an argument to be made regarding the workload of this project. Throughout the development of this game, I will treat it as if it's an actual product, and attempt to make it as good as possible, rather than just a minimal viable product that is only made to evaluate the proposed design strategy. However, I do have limited time and resources available, and this does inevitably affect certain decisions. Procedural generation allows developers to create a lot of content in relatively little time, lowering the overall workload [NS5, NS64]. Although I do consider procedural level generation to be the best choice for the case study game regardless of this argument, the relatively low workload associated with procedural generation is still an advantage for me as a developer.

The abovementioned advantages of procedural generation, as well as its downsides and the implementation of the procedural generation algorithm in the case study game, are discussed further in Section 6.7.

## 5.4 Adjustable pacing

Since this game is meant to be applicable to a range of different (rehabilitation) exercises, it follows that not every exercise will be the same in terms of (reset) timing, effort required, precision, and even whether or not the specific motion is entirely controllable by the player (e.g. breathing, blinking). This problem was already touched upon in Section 3.3.2. The physical effort required to interact with a game is called the physical response effort, and although there seem to be no special metrics defined to measure this, it has been noted to affect the quality of the gaming experience [170].

In order to be able to design a sense of flow, progression, proper difficulty curve and pacing of the game, narrative, and other many things, designers need a sense of when the average player will reach what point in the game [245]. If there exists significant variation regarding the input durations or their associated physical response effort between players (e.g. one player has to move their entire body to perform a jump while another player only has to squeeze a ball), it is much harder for designers to guide these players towards their intended experience.

The proposed solution to this problem is what this report refers to as 'adjustable level pacing', which is where certain elements of a level (e.g. the density of hazards or the overall timescale) can be tweaked to accommodate for the differences in physical response effort (and timing) caused by the variety of different physical exercises that are used to control the game. For example; A player who controls their jump by a quick and easy to reset motion, like squeezing a ball, will have to perform the jump relatively frequently, but a player who must perform an action with a higher physical response effort in order to jump, such as extending their legs, won't have to perform the jump as frequently.

Ensuring that the game is able to use as many different exercises as possible as inputs is important in order to ensure the game, as a product, can be applied across a wide variety of use cases. However, it should be noted that this functionality is rather ambitious, and its effects on elements like the fun of the game are still unknown. If this game was to become an actual product, rather than just a means of evaluating the design strategy proposed in Section

3, implementing new ways to ensure the game can accommodate a broad range of rehabilitation exercises will become more important to the game's success.

# 6 Design Decisions

This chapter describes the development process of the case study game and explains the rationale behind some of the main design decisions. This chapter is not a chronological retelling of the development process, but rather more of a general summary. Sections 6.1 - 6.4 are dedicated to stylistic and aesthetic decisions, which were typically made in the early stages of development. Sections 6.5 - 6.8 relate more to the game mechanics, such as the player movement and implementation of challenge. Lastly, Section 6.9 reflects on the game and lists some features that did not make it into the final product.

Partly due to my design philosophy of using solutions that affect multiple aspects of the game at once (see Section 5.3), not all design decisions fall neatly into the abovementioned categories. For example: Mechanics like permadeath and procedural level generation (discussed in Sections 6.6 and 6.7 respectively) are gameplay-related mechanics, but also form the cornerstone of the roguelike genre [NS60], which is discussed in Section 6.2.2.

## 6.1 Before we start

The case study game will be developed using the Unity engine. Game engines take care of a big part of the work and code that will be identical or similar for most games (e.g. physics, collision detection, etc.), and provide a basic framework to build a game upon. I will use Unity since it is freely available, widely used, and as such, comes with a lot of online documentation, is well represented on online forums such as StackOverflow, and has a lot of (freely) available assets. It is also the engine that I'm personally most experienced working with.

Aside from the engine, the decision to make the game 2D was also made right at the start. Usually, such a choice follows from previously made decisions; e.g. if you really want to make a first-person shooter, it follows somewhat naturally that it will be a 3D game. The primary reason for this decision is that (most) 2D games require less time and resources to make compared to 3D games [NS18]. Despite being 2D, the case study game will still take inspiration from literature on- and experiences with 3D games. This is not at all uncommon though, and, generally speaking, there is a lot of transferable skill between 2D and 3D game design [NS10].

## 6.2 Game genre

Even when limited to just 2D games, there is a huge variety in the types of games that can be developed. Puzzle platformers (e.g. Limbo, GRIS), top-down shooters (e.g. Enter The Gungeon, Hyper Light Drifter), Metroidvenias (e.g. Hollow knight, Blasphemous), Roguelikes (e.g. Dead Cells, Hades), RPGs (e.g. Darkest Dungeon, Undertale), Survival games (e.g. Don't Starve), and

Social games (e.g. Among us, Battleblock Theater) are all 2D games, despite offering completely different experiences to the player.

### 6.2.1 Action platformer

The case study game will be a 2D roguelike action platformer. The player will have to traverse uneven terrain riddled with hazards, as well as fight a variety of different enemies. The goal of the player is to make it to the end of the level without dying, but the game will incentivise the player to explore the level completely in order to collect as many resources as possible for the next level. The primary mechanics will be the movement (running, jumping, wall jumping, double jumping), as well as attacking (directional / timed attacking, attacking downwards on enemies / hazards as a platforming tool). These mechanics are explained in detail in Section 6.5.

There are a few reasons for the decision to create a 2D action platformer. Action platformers are a well-known genre, with clear conventions and affordances [175]. Derek Yu mentioned how he was able to easily explain his game Spelunky by comparing it to another platformer: Mario [268]; "Whether or not you play videogames, you've heard of Mario.". For me, this means that the case study game will be relatively easy to understand, even for inexperienced gamers.

The traditionally simple mechanics of 2D platformers are easy and intuitive to learn for most gamers [NS4], yet offer great potential for unique, creative, and challenging level design. It also allows me to focus on satisfying movement and moment-to-moment gameplay, rather than other characteristics that are less suited for the intended application of my game, such as story, puzzles, exploration, discovery, aesthetics, or humor. The reasoning behind this focus is explained in Section 5.3.

Lastly, 2D platformers are relatively easy to make [NS18]. Due to their immense popularity and ubiquitousness, there are a lot of tools available within most game engines that specifically support the development of these games, as well as a lot of reference and inspiration material. Personally, I also have more experience with 2D platformers compared to some other, more specific 2D genres, like top-down shooters or survival games. Lastly, the traditionally simple mechanics of 2D platformers are better suited for procedural generation [NS4]. This is discussed in more detail in Section 6.7.2.

On a final note, let's highlight the distinction between speed and technical platformers. Speed-based platformers are games like Sonic, and are focused on gaining and maintaining momentum, whilst technical platformers, which are games such as Mario, focus on testing the player's platforming abilities with a variety of challenges, and generally don't care about the speed with which these are completed [NS19]. Designing levels for speed-based platformers generally requires far more work than for technical platformers, since they require more intentional level design, testing, and often also larger levels to encourage the intended type of gameplay [NS19]. The case study game will be a technical platformer, since I believe this best suits the intended application, with the added benefit of a reduced workload, relatively speaking.

### 6.2.2 Roguelike

The previous section also listed the term 'Roguelike' to describe the genre of the case study game. Roguelikes are games that resemble Rogue, the 1980 dungeon crawling videogame created by Michael Toy and Glenn Wichman with later contributions by Ken Arnold[10] [33][NS60, NS53]. Rogue draws heavy inspirations from 'Dungeons and Dragons' and 'Adventure', and has the player explore procedurally generated Dungeons of Doom to retrieve the Amulet of Yendor [33].

Rogue distinguished itself from other contemporary games by focusing its core gameplay elements around randomly generated levels and items [33]. Rogue's popularity led to derivatives known as 'roguelikes'[11], and although these found popularity within certain niches of gamers, they have received little recognition in mainstream gaming [33]. In addition to the obtuse interface and ASCII graphics, roguelikes have gained a reputation for being extremely difficult, where it is possible for players to go for years without a win [NS66].

While many roguelikes, like Hack, aimed to be a direct descendant of Rogue and deliberately tried to recreate the original game whilst adding modifications and improvements, other games were being developed in the 1980s that were similar to Rogue, but not necessarily direct descendants. These games were intended to be more than just modifications and enhancements to Rogue, yet, they're still considered to be a part of the roguelike genre [33].

For a long time, roguelike games never really went beyond this [NS53], however, with advancements in technology, later roguelikes would sometimes replace the ASCII graphics with a graphical tileset [33]. In the early 2000s, certain roguelike developers aimed to target a broader audience by reducing the overall difficulty and learning curve. Other developers aimed to do the same by removing certain features that made them difficult for new gamers [33]. For example, games like Dungeon Hack offered randomized dungeons, but with a first-person perspective and savepoints, or Diablo, which has randomly generated levels with real-time play. These creative approaches helped to expand the appeal of the genre and energized the development community [33].

[10]'Roguelike' refers to a genre, not merely 'like-Rogue'. The genre is represented by its canon. The canon for Roguelikes is ADOM, Angband, Crawl, Nethack, and Rogue. - From the Berlin Interpretation of Roguelikes [NS6]

[11]Note that not all games that draw heavy inspiration from Rogue are called 'Roguelikes'. Dungeon crawlers like Diablo, as well as sandbox games like Dwarf Fortress and Minecraft, despite containing a great deal of randomly generated content, and drawing inspiration from Rogue, aren't technically considered roguelikes.

This also blurred the line for what could be considered a roguelike, and in an attempt to establish more defined parameters for the genre, the 2008 International Roguelike Development Conference in Berlin offered 'The Berlin interpretation of roguelikes' [NS6, NS53]. This definition lists a number of high- and low-value factors that can be used to define a roguelike [NS53] as summarized in Table 3. Please note that this definition remains open to interpretation, specifically stating how: "Missing some points does not mean the game is not a roguelike. Likewise, possessing some points does not mean the game is a roguelike. The purpose of the definition is for the roguelike community to better understand what the community is studying. It is not to place constraints on developers or games" [NS6]. This is in line with my own game-design philosophy as described in Section 2.1 - games shouldn't restrict themselves to fit into a certain genre, (new) genres should expand or arise to encompass a wide variety of games.

| High-Value Factors | Low-Value Factors |
|---|---|
| • Random environment generation<br>• Permadeath<br>• Turn-based<br>• Grid-based<br>• Non-modal<br>• Complexity<br>• Resource management<br>• Hack'n'slash<br>• Exploration and discovery | • Single player character<br>• Monsters are similar to players<br>• Tactical challenge<br>• ASCII display<br>• Dungeons<br>• Numbers |

Table 3: High- and Low value factors for the Berlin definition of a roguelike[12]

In more recent times, the term roguelike has been commandeered to describe a whole fleet of (indie) titles that share 2 important characteristics; Random level generation and permadeath [NS60]. The case study game will contain both of these mechanics, which are discussed in Sections 6.7 (Procedural generation) and 6.6 (Permadeath), and can therefore be categorized as a 'roguelike'[13].

## 6.3 Artstyle

Both 2D and 3D games can follow a variety of art styles. Common art styles for 2D games include vector art, pixel art, monochromatic art, cutout art, flat art, and pre-rendered 3D art [NS3]. Choosing an art style for your game is a very

[12] Please consult `http://www.roguebasin.com/index.php?title=Berlin_Interpretation` for a more detailed description of each factor.

[13] There is some discussion regarding the distinction between roguelikes and so-called roguelites. This is touched upon in Section 6.6

consequential decision, since it will determine the entire look of the game, as well as have a significant impact on the development process. Wu [266] suggests that visual style in a videogame shapes players' gaming experience in terms of three salient dimensions: narrative pleasure, ludic challenge, and aesthetic reward. Mitchell et al. [167] lists a game aesthetic among the features that can potentially impact its instructional goals.

Although high fidelity is considered to be of importance where transfer of knowledge learned within the game to real-world situations is sought [192][14], there are other factors that pull me towards a lower fidelity artstyle. Close correspondence between real and virtual space is a potential determinant of the learning transfer [169]. However, some authors argue that lower fidelity may benefit learning through the simplification of reality [264].

Regardless, a game's verisimilitude's impact on the transfer of knowledge was only a small factor in my decision making. Other factors such as previous experience with creating assets in different art styles, the associated workload, and the impact the artstyle has on the readability of the game were of greater importance.

In the end, I chose to use pixel art for the case study game. It is the art style that I'm most experienced with[15]. It allows for relatively quick and easy asset creation. It keeps the application lightweight and efficient. It can easily translate into tilemaps which are useful for procedural generation. And, for pixel art specifically, there exists an additional benefit, which is the nostalgia this style evokes for some people [NS52, NS11].

## 6.4 Thematics & setting

At this point in time I had a clear picture of what I wanted the player to be able to do (their movement options, attacks, etc.), and some ideas for obstacles to challenge the player's abilities. But before I could really get started with asset creation, the overall setting of the game needed to be defined. Although I knew how the game was going to be played, the decision of what the game was going to look like was yet to be made (e.g: Does the game take place on an alien spaceship? Or maybe in a post-apocalyptic abandoned city?). Fabricatore et al. [76] define this distinction as follows: "Information managed by the player during the interactive cycle can be divided into two categories: functional and aesthetic. Functional information allows the player to undertake the activities he/she is supposed to carry out in order to win the game. Aesthetic information defines most aspects of the context in which the game takes place, and is mainly aimed at rendering an atmosphere capable of drawing and maintaining players' attention on an emotive basis, making them feel part of an entailing virtual world". The setting of the game serves as the basis for the aesthetic information within the interactive cycle.

[14] It's uncertain whether this is also applicable to 2D games

[15] I developed a game called 'Drunken Ducklings' using the same pixel art tool before

Choosing the correct setting for the case study game is very important. The context (story, setting, goals) of a game can be considered one of the three key determinants of the quality of a game [74, 76]. Bellotti et al. [20] states how good serious games challenge players, sense immersive situations, providing concrete, compelling contexts where the player gets concretely involved, also highlighting the importance of the overall setting of a game. Visual language in games is generally also more effective when it makes contextual narrative sense within the game world [245]. The setting I choose for the game will also affect the type of assets that need to be created, and, to some extent, the art style.

The 2 primary considerations when deciding on a setting for the case study game were to offer a reasonable explanation for in-game objects and events, and to maintain a broad playerbase. These considerations are discussed in the sections below.

### 6.4.1 Contextual realism

Mainly, I just wanted to ensure that the ideas I already had for the game could reasonably be explained by the overall setting of the game. For example: I knew the player was going to carry some kind of melee weapon that would serve as a tool both in combat as well as in platforming. But, if the game takes place in a futuristic setting, why would the player only be armed with a primitive melee weapon if the enemies can have laser guns? The player also has a lot of movement options and as such, the levels require sufficient complexity to challenge the player's platforming abilities. This requires some unusual geometry. If the game takes place in an office building, the unusual geometry would appear out of place. And although form should follow function at this stage, it is important that things in your level make sense contextually and diegetically [245]. The goal should be to make something believable, not necessarily something realistic [NS37]. It is also important to consider that I didn't have a clear list of all the types of hazards and enemies I wanted in the game at this point in time, so I wanted the setting of the game to offer sufficient freedom to add new things later.

### 6.4.2 Content appropriateness

The second consideration to determining the setting of the game was to maintain a broad playerbase. The setting, thematics, and context of the game should not deter any otherwise interested players. A very niche and specific setting such as a historical event may not be equally appealing to all players. The same holds true for settings that are scary, violent, sexual, culturally insensitive, etc. Considerations such as these fall under the term 'Content appropriateness', and are relevant for both serious and non-serious games [168]. Peixoto et al. [190] suggest that content appropriateness is also concerned with evaluating the fidelity of the external world that the game represents. Essentially, I want the case study game to appeal to a broad audience and not deter any players by being inappropriate.

### 6.4.3 The setting of the game

In the end, I landed on a feudal Japan-like setting with some fantasy elements. This setting meets all my requirements. It explains why the player is armed with a melee weapon. It provides sufficient options for interesting enemies / level hazards that each play a different role in the gameplay and each present an unique challenge to the player. The fantasy elements lighten the mood and are meant to increase the player's willful suspension of disbelief, whilst also broadening the options for potential enemies / level hazards even further. It is also accessible, since most people, regardless of age or culture, are familiar with concepts such as samurai and ninjas.

The only real argument against it could be that it could potentially be considered a form of cultural appropriation. But the references are never explicitly made, the fantasy elements can give it a more unique appeal / personality, and compared to some other games, the references / inspiration is far more subtle.

### 6.4.4 The visual design of the player character

Although the final version of the player character was only implemented towards the end of the game's development[16], the requirements to which its visual design had to adhere were clear from the start. The player character must fit in with the artstyle of the game, but also be distinguishable enough for players to immediately recognize it. If the player character would blend in with parts of the environment, it could confuse players and make the game more difficult.

The character should also be designed such that players can easily identify with it. The design intentionally doesn't include features that can hint at the character's gender, race, etc. This way, all players can place themselves in the shoes of the player character. Veiling the player character's identifiable attributes was also in line with the game's thematics, since it fits well with the character's ninja-like aesthetic. The dark body and deep blue cloak of the player give it a mysterious appearance, whilst the contrasting bright pink eyes give the player more character and make it easier to quickly spot it. Another notable feature is the katana that the player carries on their back. The sharp angles contrast with the character's otherwise more rounded shape. The weapon itself fits in nicely with the feudal Japanese thematics of the game. Figure 1 shows the player character in various poses.

[16]The knight from Hollow Knight was used as a placeholder. I still had an animated version of the knight from a previous project. Given the inspiration drawn from Hollow Knight, and the similarities in movement options, it seemed like a natural choice for a placeholder.

Figure 1: A few sprites that show the player character in various poses. From left to right, it shows sprites taken from the idle, attack sideways, attack downwards, double jump, and fall animations.

## 6.5 Designing a character controller

After creating a new Unity project, creating the character controller, as well as a little playground level to experiment / playtest all the movements in, was the first thing on the agenda. My intention was to fully complete and polish the character controller before moving on to other things like level design or enemies.

It's been said that for the first few months of the development of Mario 64, the developers worked exclusively on Mario's movement. They fine-tuned every aspect of his movement, and, because of this, the character feels so good to control [NS51]. Anything beyond that, the levels and the enemies, exists primarily to facilitate / challenge the player character [NS51].

The development of the character controller in Hollow Knight followed the same strategy; the player's movement was the very first thing that was coded and only after completely polishing that, did the developers move on to other aspects of the game such as designing the levels [NS49]. Hollow Knight has one of my all-time favourite character controllers and served as a major inspiration to the character controller in the case study game[17].

This method of developing the player's movement before doing anything else is able to create great character controllers, and the reasoning behind this is as follows: Fundamentally, there are two kinds of interactive things in platformers; mechanics and hazards. Mechanics are the player's basic movements and the things that can alter that movement (e.g. a wall to walljump off alters their regular jump, a slippery surface alters their run). Hazards and enemies are there to create challenge to test the player's mechanical ability [NS15].

This method of character controller development ensures that the mechanical aspect is completed first, essentially confronting developers with the question

[17]The primary inspirations for the character movement in the case study game came from Hollow Knight, Dead Cells, Celeste, Broforce, and ReIterate.

of whether their game feels fun to control even when devoid of challenge; the game should be fun to just move around in [NS15].

This bare-bones testing and tweaking period in the development is crucial for getting the parameters of the player's movement just right [NS18]. There are plenty of platformers that are hampered by loose controls and stodgy movement [NS51, NS35], and especially given the intended use case of my game and its focus on moment-to-moment gameplay, smooth, controllable, and satisfying movement is vital. This tweaking of the parameters generally requires lots of intuition, experience, and experimentation by the developers [NS35]. An additional benefit to this method is that finishing the player's movement first also provides developers with a clear metric of the player's abilities (e.g. how far can the player jump?), which can help design levels that are well-tailored for the player's moveset and challenge their abilities to the fullest [245][NS16].

Snappy, satisfying, and controllable movement options are important for a number of reasons. Breuer & Bente [32] list micro-level interactivity (individual inputs) as a crucial reason for the attractiveness of digital games, and emphasize how this contributes to a game's entertainment value, despite their requirement for learning, effort, and a willingness to invest time and resources - something often experienced as unpleasant in different contexts. User control within the gaming environment, as well as satisfaction with the interactive features of a game, are also considered key characteristics for the usability of a game [109], which is a fundamental requirement for users to have a positive gaming experience [120].

A controllable player character is also important to make the game feel fair, even when difficult [NS17]. If the player's movement feels stodgy or floaty, and the player does not feel in total control of the character, the challenges posed by the game may be perceived as unfair [NS48]. This is especially important for my game, since it is my intention to make the game rather challenging for most players (see Section 6.8).

Then, there is game feel: Game feel (sometimes called 'Game juice') is an mostly abstract, subjective, largely invisible art, but getting it right is essential when making a great platformer game [NS51]. It is a feeling that accumulates from satisfying controls and feedback, and it is something that players can detect immediately [NS51]. Things like screen shake, controller vibration, enemy knockback, art / animation, particle effects such as dust, blood, or sparks, sound effects, or even something as simple as enlarging an object, can make the impact of an in-game action feel much more intense and satisfying [NS35, NS51, NS12]. Making something feel powerful is key to ingraining it in the player's mind [NS38].

Lastly, since the intended use case of the case study game is to assist with physical therapy, (some of) its inputs will be based on exercises performed by the players. Ideally, the GACE mappings of these exercises ensure smooth inputs so that, despite the unconventional input methods, the game controls as intended. However, problems may arise here that may negatively influence the way in which the exercises are translated into the player character's movements (e.g. additional input lag, hardware inaccuracies, etc.). Difficulty with the controls, whether it's due to the game, the hardware, or even due to a player's disability, can deter certain players [27, 269][NS65]. In his book 'Glued to games', Scott Rigby [208] states that "When people are discouraged by a game's controls, they don't even have the chance to feel competent at the gameplay, because they can't even get to the real game. For them, the price of admission to the fun of games is so high, they often stay outside the turnstile". A snappy character controller may not completely erase this problem, but at least it won't amplify it, and it might even negate it to some extent, hopefully turning this into a non-critical barrier.

### 6.5.1 Final moveset

The final moveset of the player doesn't stray too far from traditional platformer movement design; the player can run, jump, wall climb, wall jump, double jump, and spike jump, as well as attack sideways, upwards, or downwards. Many of these moves can be used in tandem with each other and with the level hazards. Each move is explained in more detail below.

- **Run:** While grounded, the player can run to either side. The player character accelerates to its top speed in about 300ms, over the distance of 1 tile. The relatively slow acceleration is meant to make the player character feel weighty and real. This is emphasized by the animation, as the player character initially leans in when beginning to run, as well as dust particles on the ground. The top speed of the player is constant and is about 6 tiles per second. It also takes around 300ms and the distance of 1 tile to come to a complete standstill from full speed. This deceleration is again emphasized by the animation and dust particles. The player can also brake over a far shorter distance (approx. 0.2 tiles) when initiating the run in the opposite direction. This is also emphasized by an unique turning animation and dust particles.

  Regarding GACE mapping, the run takes a continuous input, with both directional and amplitude control. When using a controller, the direction of the analog stick, as well as how far it is pushed, are both used to control the run. This would make the run suited for exercises where both of these elements are relevant (e.g. move a limb to a certain direction).

- **Jump:** When grounded[18], the player can initiate a single jump. The jump is a powerful tool for both platforming and combat. The height of the jump is dependent on the duration with which the jump button is pressed, ranging from a minimum jump height of 1.75 tiles to a maximum jump height of 3.25 tiles. It takes about 250ms and 800ms respectively to

[18] Or while coyote time is active, see Section 6.5.2 for details.

reach these heights. The double jump also cannot be initiated whilst the minimum jump height of 1.75 tiles has not been achieved yet. It the jump button is released before the minimum jump height is achieved, the player character will continue jumping until it reaches the minimum jump height.

The jump can cover a horizontal distance of about 10 tiles (when not using wall climbs). The exact horizontal distance that can be covered also depends on the height difference between the player and their goal position. These options are illustrated in Figure 2. The relatively large horizontal distance that can be covered with a single jump is largely due to the long hang time of the jump. The player character ascends and descends somewhat fast, but the jump has a lot of hang time. This allows the player to precisely plan and execute their landing. The shape of the jump creates an arc, which is generally perceived as being an intuitive and predictable path for most players [NS12]. Both the jump and landing are emphasized with particles and animation, whilst the mid-air loop animation intends to make the player feel light and floaty, yet controllable.

Regarding GACE mapping, the jump is a single action with amplitude control; the longer the button is pressed, the longer the jump will continue ascending. Exercises that take a while to perform or have to be held for a certain amount of time (e.g. squeezing a ball), are fit to be used as inputs for this mechanic.

- **Wall climb:** When the player character jumps onto a wall, the character will stick to that wall as long as the player is steering into it. Whilst wall climbing, the player will slide down about 1.8 tiles each second. Sliding down the wall rather than just clinging to it adds time pressure to perform the next movement, providing some additional challenge [NS16]. The wall climb state can be exited by discontinuing to steer into the wall, sliding down to a point where there is no more wall, which will make the player fall down vertically, climb jumping off the wall, or hitting ground when sliding down.

  Regarding GACE mapping, wall climbing uses the same controls as running, so the same type of exercises are applicable here.

- **Wall jump:** Whilst wall climbing, the player can initiate a wall jump. The wall jump works similar to the single jump, but also launches the player away from the wall. Because, in order to wall climb, the player has to steer into the wall, the player input regarding horizontal movement is ignored for 350ms. During this time, the character controller acts as if the player is steering away from the wall. This causes the player to move approx. 2.15 tiles away from the wall horizontally. If, after this time, the player is still steering into the wall, the player character will start to move to the wall again. Simply continuing to steer into the wall and pressing wall jump will make the player ascend with 3 tiles per wall jump.

  If after the 350ms time during which the input is ignored the player has started to steer away from the wall, the wall jump will act like a regular jump (during which the player has steered in this direction). If the player stopped steering in one direction altogether, the player character will fall down vertically.

Regarding GACE mapping, wall jumping is a mix between steering and jumping, meaning both the examples from running and jumping can be applied here.

- **Double jump:** Whilst airborne, the player is able to initiate a double jump. Being grounded, wall climbing, spike jumping, or taking damage resets this ability. Just like the single jump, the double jump can be held down to extend its vertical reach. The maximum achievable vertical ascent with the double jump is approx. 3.25 tiles, and reaching this takes about 800ms (somewhat dependent on the player's velocity when initiating the double jump). When combined with the single jump, it can allow the player to traverse quite some distance, as is illustrated in Figure 2.

  However, unlike the single jump, the double jump has no minimum jump height or duration. This means that it can also be used quickly, to simply reset the player character's vertical velocity and provide some extra hang time to reposition.

  Regarding GACE mapping, the double jump is, same as the single jump, a single action with amplitude control, and can be controlled using the same examples as given in the single jump section.

- **Attack:** The player has a sword with which it can attack either sideways, upwards, or, when airborne, downwards. This direction is determined by the direction in which the player is steering. This also means that the player isn't limited to steering horizontally, but can steer vertically as well. The attack itself is initiated by pressing a button. If the player isn't steering in any direction, the character will attack sideways in whichever direction it is currently facing.

  The attack has a slight recoil on the player, as well as on the enemy (if the hit connects). This, combined with the flashy attack sprite, and sparks or blood particles, makes the attack appear hefty and vicious, yet quick and flashy.

  Regarding GACE mapping, since the attack is initiated with a single button press, but the direction is determined by steering, it is a single action with directional control. This means that for the direction part, the same examples as given in the run section hold true, but for the single action, different exercises such as hitting a button or blinking can be applied.

- **Spike jump:** The spike jump is a special kind of jump that can be achieved by hitting certain objects with a downward attack whilst airborne. Certain level hazards such as spikes and some traps, enemies, projectiles, and some destructible assets can all be used to initiate a spikejump. The spike jump forces the player to time their attacks correctly, as they need to attack the obstacle before they fall on it, but not too early or they might miss it.

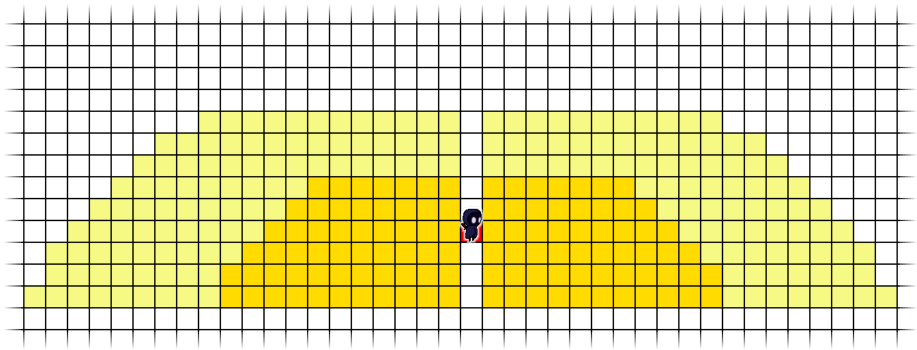


Figure 2: The movement options of the player character. The orange is are platforms accessible with a single jump and the yellow with a single and double jump. Note that this does not take wall climbing into account.

Executing a spike jump correctly will give the player a vertical boost of 1.75 tiles over a duration of 500ms. This vertical boost can be interrupted using the double jump, but if it isn't, it will always follow these exact metrics.

Regarding GACE mapping, the spike jump is a mix between jumping (as the player needs to be airborne in order to attack downwards), steering (the player needs to steer downwards), and attacking. It mixes the above-mentioned mechanics into a single, more challenging, action. And, as such, the example exercises given above apply here as well.

### 6.5.2 Invisible aid

There are several invisible methods that game developers employ to enhance the 'feel' of a game. This mainly boils down to ensuring the player character behaves according to the player's intent, even if their actual inputs can be slightly off [NS35]. (Invisible) Systems that correct for small errors like aim assist, coyote time, or input buffering can go a long way in making gameplay feel smooth and fair, as well as maintaining the hero fantasy presented to the player [NS35, NS63]. Giving the player more leniency than they think they have helps correct for player bias; the phenomenon where players think that they're better than they actually are [NS16]. Aside from 'game feel', these systems also influence other characteristics of the game, such as difficulty and accessibility.

The case study game has incorporated some mechanics that serve this same goal; they aren't meant to be noticeable by the players but they're crucial for the 'feel' of the game. The most important examples are listed below.

- **Coyote Time** refers to the time window during which a player is still able to initiate a jump even after leaving a platform [NS35]. This means that if the player runs off a platform with the intent of jumping to a new one at the very last moment, their timing doesn't have to be perfect. This gives the player not only some extra time to initiate the jump but also potentially some extra distance to their jump. The levels in the case study game are designed with the movement metrics in mind, and won't offer the player jumps that look plausible yet are impossible to make, this is important for the gameplay to feel intuitive and fair [245][NS48]. However, the 85 milliseconds coyote time in the case study game give the player just a little leniency. The double jump also offers them the means to return back to the original platform in case they initiate the jump after the coyote time has run out.

- **Input buffering** is the act of remembering player inputs for a short period of time after they're given. The case study game incorporates input buffering for jumping, double jumping, and attacking. For example: After each attack, there is a short cooldown time during which the player cannot initiate a second attack yet (300 milliseconds when grounded, 425 milliseconds when mid-air). This interval is there to encourage players to properly time their attacks rather than spam the attack button. However, if a player initiates an attack just before this cooldown time ends, the game will remember the input, and initiate the attack as soon as the cooldown time has ended.

  The same principle is also applied with jumping; if the player initiates a jump just before they land on the ground (and they do not have a double jump left), the game will remember the input and initiate the jump as soon as the player hits the ground. Attack inputs are buffered for 75 milliseconds and jump inputs for 125 milliseconds.

- **Forgiving hitboxes:** The hitboxes in the case study game are generally a little bit smaller than their respective sprites would indicate[19], meaning you can come a little bit closer to certain obstacles without getting hit. There are exceptions to this, such as the hitboxes on the spikes or shurikens. This is because the player can also interact with these hazards by attacking them (e.g. spike jumping, returning shurikens). The hitbox on the player's attack is also larger than the sprite would suggest. Most notably, the hitbox is a bit wider when attacking downwards, making spikejumps more forgiving.

- **Safe respawns:** The case study game employs a safe respawn system that aims to prevent the player from losing a lot of health due to a single mistake. If the player is hit by an environmental hazard such as spikes or thorns twice, without landing on safe ground[20] in between, the player will

[19]In hindsight, this difference between sprite and hitbox should probably have been even larger, since multiple players still perceived the hitboxes as being too large for their respective sprites (see Section 8 or Appendix G).

[20]In this context 'safe ground' simply refers to a stationary, non-destructible ground tile that does not contain any hazards or enemies.

respawn on the most recently touched part of safe ground. This typically puts the player right back in front of the obstacle to try again. These quick respawns prevent the player from getting stuck in an obstacle and losing a lot of health, thus lowering the punishment for failure. Additionally, putting the player right back in the action again lowers the overall frustration caused by the punishment, enhances the pacing of the game, and helps to maintain the 'flow' state of the player [NS29, NS13, NS39].

Note that getting hit once doesn't respawn the player yet. Getting hit even resets the player's double jump, giving them the means to reposition to safe ground or even complete the challenge. The system only intervenes if it senses that the player is stuck and can't get out using their own abilities.

- **Aim assist** improves the speed and accuracy of target acquisition by manipulating a number of factors, such as the size of the target in motor space [255], reducing the control-to-display ratio of the cursor when it is over the target [44, 263], or target gravity; attracting the cursor to the target using a simulated gravity function [18]. Aim assistance techniques have been shown to improve targeting in 2D games, especially for more novice players, and have been successfully applied to balance for unequal skill [254, 18]. Bateman et al. [18] also stated how the usage of these techniques wasn't obvious to the players, and generally went unnoticed. This is important for the application in my game, since I don't want the players to feel like the game is secretly helping them, even though it is.

  Despite the abovementioned advantages, the implementation of aim assist within the case study game is rather limited, largely due to the lack of projectiles within the game[21]. Its primary usage can be seen with the 'Shuriken Thrower' enemy. While aggroed, this enemy will throw shurikens at the player at regular intervals. These shurikens can be returned by hitting them at the right moment, meaning the player is able to shoot them back at the enemy. This is an useful method of combating this type of enemy, since they also have the habit of dodging away when the player approaches them.

  There are a number of design choices made to make this process easier; e.g. the shurikens more rather slowly when thrown by the enemy, giving the player ample time to deflect or dodge, but they move fast after getting deflected - not granting the enemies this advantage. The primary aim assist technique employed in the game is that, rather than simply deflecting the shuriken in the direction it would naturally go, the directions stick to be either directly back at the enemy, towards a different enemy, straight horizontal, or straight vertical. This makes aiming shurikens much easier.

[21]Given more time, I would have liked to introduce more enemies and hazards that employ projectile-based attacks.

## 6.6 Permadeath

Permadeath is a common feature across major roguelike branches [33]. Permadeath means that, if the player dies, the save file is essentially deleted, and they have to play the game from the very start again [33][NS60]. The case study game also features permadeath[22].

There are 2 primary reasons for the inclusion of this feature in the game. The first reason is that it makes each decision more meaningful, especially further in the playthrough. A single mistake can cause a game over, and a game over can potentially nullify hours of gameplay; it is vital to be skillful at the game.

Besides the fact that players generally already dislike missing content [245], exploration is encouraged even more in my game. Players should aim to collect all the available resources in the level, since they will likely need these to survive the harder levels later on. However, this exploration also forces them to engage with enemies and environmental hazards. The only way to survive is to master the mechanics of the game and survive these encounters without losing resources. Rewarding player skill is one of the primary advantages of permadeath as a game mechanic [NS60]. This balance between risk aversion in order to prevent losing resources and requiring the player to take risks in order to collect new resources is very interesting, and can be applied in creative ways (e.g. cursed chests / challenge rifts in Dead Cells, hidden bonus levels in Enter The Gungeon).

The second argument for permadeath is to promote shorter gaming sessions. I personally noticed whilst playing Dead Cells, that dying, after a playthrough that lasted an hour or so, often made me quit the game. However, I still came back the next day to play again.

Given the focus on promoting intrinsic motivation in this report, incentivising players to quit after a short session might initially seem like a disadvantage. However, given the intended application as an aid with physical rehabilitation, one playthrough attempt per day (approx. 1 hour) seems like a proper amount of game time. If the people were to play this game for hours at a time, it follows that they will be done with it in a shorter timespan (e.g. 1 hour a day for 20 days vs. 4 hours a day for 5 days), given that the game has a fixed, limited amount of content to it, that, on average, takes people a certain amount of time to complete.

### 6.6.1 Persistent upgrades

A major downside to permadeath is that it can make a failed playthrough seem meaningless. Although the player's skill will have improved with practice, this is usually not really experienced as a tangible reward [NS60]. This is why certain games have included permanent upgrades, that carry over to future

[22] This is not very relevant for the experiment, as participants only play a single, short level at a time (see Section 7.3). However, the actual product is intended to have multiple levels that all have to be completed in the same run.

playthroughs. Informally, games that feature persistent upgrades are called roguelites (e.g. Dead Cells, Hades, Rogue Legacy), whilst games that do not feature persistent upgrades are called roguelikes (e.g. Spelunky) [33] [NS60][23]. Table 4 highlights the main distinctions between roguelikes and roguelites, as well as the advantages and disadvantages of each method.

| | **No permanent upgrades** | **Permanent upgrades** |
|---|---|---|
| (Informal) name | Roguelike | Roguelite |
| Advantages | • Almost exclusively rewards player skill.<br>• No arbitrary barriers to victory: No important unlocks that are unavailable at the start but essentially required for completing the game (e.g. Health flasks in Dead Cells). | • Every run feels meaningful.<br>• Allows players of essentially all skill levels to finish the game at some point. |
| Disadvantages | • Failed playthroughs offer no tangible reward and can feel meaningless.<br>• Consistent skill requirement means that players of different skill levels can have vastly differing experiences with the same game. | • Strange difficulty curve: The game starts off being the hardest and gets easier over time.<br>• Success within the game can be less dependent on improved skill and more so on progression of the character.<br>• Winning can feel less meaningful since it can't be entirely attributed to player skill, but also to progression of the character. |

Table 4: The primary advantages and disadvantages of roguelikes and roguelites compared.

Naturally, game designers have come up with clever methods to help negate the disadvantages of either method (e.g. unlocking items that do not help beat the game but still feel rewarding to unlock, such as cosmetics, lore, achievements, or new playable characters) [NS60].

The case study game will follow the roguelite design, and incorporate persistent upgrades. These will likely not be things that the player receives from the very start, but different, often better, items that can randomly spawn once unlocked. This concept is similar to that of Dead Cells or Enter the Gungeon,

[23]Given that they do adhere to other criteria such as permadeath and random level generation.

where items are unlocked permanently, but can only be obtained by the player if they encounter them in the game.

## 6.7 Procedural level generation

The case study game uses procedural generation to create its levels. Procedural content generation (PCG), or algorithmic creation of game content, has been an important and active research area for several years [267, 225]. Many different sorts of game content can be procedurally generated, ranging from levels, quests, and textures, to more complex elements such as in-game lore (e.g. [NS26, NS47]), the overarching rules of a game (e.g. [132]), or even a skirt (e.g. [NS9]) [133, 132].

Naturally, PCG comes with its own unique set of advantages and challenges, which are discussed below. This section also discusses the way the PCG algorithm functions in the case study game.

### 6.7.1 Strengths

One of the main advantages attributed to procedural generation is that it enhances a game's replayability [175, 33][NS4, NS41]. Replayability is a major factor in the long-term enjoyment of a videogame [33]. Many games can be engrossing on the first playthrough, but those with fixed solutions and singular paths through multiple levels of skill can quickly lose their appeal after the first win [33]. This issue is circumvented by the use of procedural level generation.

Procedural generation also tends to make levels less predictable and prevents players from memorizing level layout / geometry [175]. This means that the game requires the player to master its mechanics, especially the moment-to-moment gameplay mechanics, rather than memorize the level layout [NS50, NS64]. By understanding the underlying skills involved in mastering randomness, games can become more meaningful [NS14]. Starting in a newly generated level every run does not only make death more consequential, it also cuts out repetition and removes the ability to commit the stages to memory [NS50]. Derek Yu, the creator of Spelunky, confirmed this as the rationale behind the choice for randomly generated levels in his book 'Spelunky' [268]. The resulting mastery of the gameplay mechanics is a key element that players use to determine the quality of a digital game [75, 74, 76].

Generating levels via script also makes it easier to adjust different parameters, such as difficulty, length, verticality, enemy density, etc. [NS64]. This allows the game to be easily tweaked for specific audiences or goals (e.g. spawn fewer assets to reduce visual noise for cognitively impaired players, generate shorter levels so the game can run on lower-end, lethargic hardware, disable certain enemies, etc.). It can also allow physical therapists to generate levels that are well-tailored to the needs of their patients (e.g. generate a level that does not contain any enemies but consists solely of platforming challenges in order to practice a patient's jump). The code can also be used to generate levels that appear visually distinct, even though they are mechanically similar (e.g. using a different tile set and color palette to make the game more suited for colorblind people, or more appropriate for children). There is a high degree of customizability that is generally relatively easy to implement.

Games that use procedural generation also tend to be more lightweight, since they do not require disk space to store the levels (or other assets that are procedurally generated) [175][NS10]. This is evident by the fact that procedural level generation algorithms were initially invented to deal with the technical limitations of contemporary hardware devices [133]. The 2004 German game .kkrieger is a good example, as it consists of (almost) 100% procedurally generated content. As a result, the game file is only 96KB, but once it is loaded it goes up to over 300MB in the task manager [NS44].

Lastly, procedural generation allows developers to create large amounts of content in a relatively short amount of time [NS5, NS64]. Procedural generation is heavily praised for its ability to create an uncountable set of levels [175]. Given the limited time and resources available to create this game, methods that lower the overall workload are preferred. Although this didn't influence my decision to employ PCG for the case study game much, for some it remains one of the primary advantages to its usage.

### 6.7.2 Weaknesses

One of the main critiques on procedurally generated content, especially levels, is that it is often considered to be of lesser quality when compared to handcrafted levels [NS4, NS64]. Although Neufeld et al. [181] showed that generated levels can achieve a similar structure to human-authored levels, relying on procedurally generated content too much can lead to bland or inconsistent level design [NS64]. Aspects like narrative, a proper dramatic arc, and a balanced difficulty curve are also harder to implement in less linear levels, which procedurally generated levels typically are [245, 258][NS7].

Then, there is the so-called "bowl of oatmeal" problem: Although each individual oat may technically be unique, with its own size, shape, and lore, players will just see a bowl of oatmeal [NS9]. Developers must ensure sufficient variation in their procedural generation formula so that the differences in the game's code / environment actually affect the player and are perceived as being unique [175][NS5, NS4]. It is important to consider both the possibility space (how many different levels could possibly be created), and the expressive range (how interesting and unique each level is individually) of the algorithm [NS9].

A common solution to both abovementioned problems is to mix handcrafted content with procedural generation [249][NS4]. Games such as Spelunky [268] and Dead Cells [NS64] both employ this strategy to great success, striking, what I personally consider to be, a fine balance between the two. Although very few games consist (almost) entirely of procedurally generated content (e.g. .kkrieger), there is a big spectrum between fully handcrafted and fully procedurally generated games [NS44]. The case study game will also balance handcrafted and generated content. The exact method with which this mix is created is described in Section 6.7.3.

Another drawback of procedural (level) generation is that, in order for it to work, the player's own interaction with the game must be kept basic [NS4]. The reason being that the algorithm has to be designed to work around every mechanic and system the player has access to. The more mechanics or abilities in the player's toolkit, the harder it will be to create something that makes use of all of it. "Spelunky worked because platform mechanics are rather simple. Attempting to procedurally generate levels that work with the time mechanic of Braid or the portals from Portal is near impossible" [NS4]. This is why the complexity of most procedurally generated games is integrated into the environment rather than the player's interaction [NS4]. This drawback doesn't really apply to the case study game, since the movement toolkit is rather simple to begin with.

One final drawback is that, generally, when using procedural generations to create levels, developers don't really have anything until they have everything [NS5]. Developers cannot start playtesting until they have a world to play in, and they won't have a world to play in until they have invested hours of coding. This issue is especially impactful in AAA development [NS5].

Although there is no one size fits all solution to the challenges posed by procedural generation [NS5], most of the drawbacks are either solvable or don't really apply to my use case to the same extent as they might for some other developers. For the case study game, the benefits of using procedural level generation vastly outweigh the downsides[24], and as such, it seems like a natural choice to use PCG.

### 6.7.3 The algorithm

This section discusses the inner working of and rationale behind the procedural level generation algorithm as it is implemented in the case study game.

Every level generated by the algorithm consists of smaller, handcrafted areas that are puzzled together. A custom scriptable object was created to represent these so-called handcrafted areas, or HCAs. The variables contained within an HCA scriptable object are explained in Table 5.

[24]There are some more challenges specific to my algorithm that are discussed in Section 6.7.4

[25]The reason for the usage of an array of Vector3Ints rather than a two dimensional array of Ints is that this allows for multiple elements to be spawned at the same coordinates (e.g. still spawn grass under on the same tile where an enemy spawns). This also allowed me to

| Variable Name | Variable Type | Description |
|---|---|---|
| Area Name | String | The name of the area |
| Area Size | Vector2Int | The size of the area |
| Connection Points | Array of Vector2Ints | An array of local coordinates that indicates on which points this HCA can connect to other HCAs. |
| Tile Indexes | Array of Vector3Ints | An array of Vector3Ints. The X and Y values represent the local coordinates while the Z value contains the index of the tile / spawnable object that is to be placed there[25]. |

Table 5: The data structure of the HCA summarized.

There are a few distinct types of HCAs, each having the same data structure but fulfilling a different role in the level generation process. The distinction is made by placing the HCAs in different arrays in the level generator script. Any single HCA could theoretically be placed into multiple arrays at once. The different HCA types are:

1. **Spawn Areas:** The area in which the player spawns. There is only a single spawn area defined in the current version of the game, but it is theoretically possible to use different spawn areas.
2. **Level End Areas:** Areas that contain a gong. Hitting the gong indicates that the level is completed. There is also only a single Level End Area defined in the current version of the game, but it is possible to add more, as well as spawn more at the same time, providing the player with multiple points to complete a level.
3. **Primary Areas:** These areas make up the vast majority of the level. This subset contains some of the larger areas and generally spawns more hazards and enemies compared to the other HCA types. These areas can also contain more than 2 connection points, allowing them to split routes and even loop back in on themselves.
4. **Filler Areas:** These are generally small areas that connect primary areas together. Usually, they're just a few geometry tiles without any hazards or enemies, although it is also possible to spawn these. They offer some reprieve in between the trials posed by the primary areas, which is generally considered desirable level design [NS20].

serialize the variables in the editor.

5. **Dead End Areas:** When the level is fully generated (the desired number of primary areas has spawned), the level generator algorithm will look and see if there are any unused connection points available. Whenever possible, the algorithm can spawn so-called Dead End Areas to these connection points. These often contain rewards, sometimes accompanied by a small challenge. These rewards don't necessarily have to be loot or pick-ups in order to feel meaningful, but can also take the form of nuggets of lore, achievements, vistas, vantage points, or even easter eggs [245]. The main goal of these areas is to reward the player for reaching the end of a path, as well as preventing the edges of HCAs from being highlighted by a hard cutoff.

Alongside the arrays of HCAs, a number of other parameters need to be defined in order for the level generator algorithm to create a level. The most important of which are the level size, length, and starting position. The level size is a Vector2Int that determines how big the grid is on which the level can be generated. If the level generation algorithm approaches the bounds of this area, it will attempt to look for another open connection point and continue generating from there. The level length represents the number of primary areas that the generation algorithm should attempt to place. The starting position is a Vector2Int that indicates where on the grid the spawn area should be placed.

Before the level generation starts, the arrays of HCAs are shuffled. When the level generator algorithm selects an HCA, it will pick one from the start of the shuffled array. The array is then iterated upon with steps of random size, ranging from 1 to 5. When the selection index exceeds the length of the array, the array is shuffled again and the selection index is reset to 0. This method is preferred over simply selecting randomly from the array because it prevents repetition (an HCA is less likely to be selected twice in a row).

At the start of the generation, the algorithm places the spawn area. After this, it alternates between spawning primary and filler areas for as long as the desired level length is not achieved, or until further placement is impossible (e.g. if there are no more open connection points available). On each iteration, an HCA is selected using the method described above. The algorithm then checks if it is possible to place this area. If it has already been placed recently, overlaps with other areas[26], or is too close to the edge of the level, it will attempt to place another HCA. If a prespecified number of attempts fail, the algorithm will look for another connection point and continue the same process from there[27]. If this also fails a prespecified number of times, the algorithm breaks its loops and returns a message that the level generation has failed.

[26] It is possible for different areas to overlap in certain conditions, and the majority of areas are actually designed to encourage this. If an area contains a lot of solid ground, everything but the edges of this ground can still be overwritten by other areas.

[27] This can also occur randomly if a certain path continues without splitting for a prespecified number of iterations.

If the desired level length has been achieved, the Level End Area is spawned. After this, the algorithm looks for available connection points and attempts to place Dead End Areas. Then, some smoothing along the edges of the placed HCAs, to ensure their geometry aligns properly. This is meant to make the areas blend together more and make it harder to identify the pieces from which the whole was created. The algorithm then runs some final optimization functions (e.g. ensuring there are no unnecessary colliders, deleting variables that are no longer needed, etc.), and finally, the actual level is drawn and the game can begin.

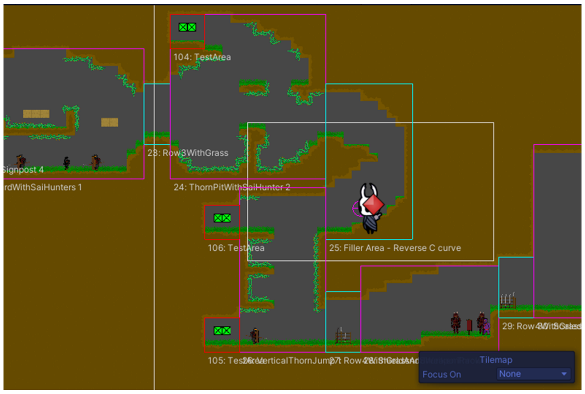
Note that this summary skips a lot of detail regarding the algorithm (e.g. potentially spawning enemies / tiles, the code used for tiles to ensure they use the correct sprite and collider based on their position, deactivating objects that are far away to enhance performance, etc.). The current version of the game contains 187 Primary areas, 47 Filler areas, 45 Dead End areas, 1 Spawn area, and 1 Level End area. However, in my experience, the way in which these areas connect, overlap, and loop back in on themselves can create entirely new situations that feel like more than the sum of their parts (see Table 6 for illustrated examples). A branching and looping structure, such as the one that this algorithm creates, can help make the world feel more alive, minimize backtracking, and encourage exploration [245].

Although the full potential of the level generation algorithm doesn't truly shine through in the short experiment for which it was needed, it is capable of creating some really fun levels that I personally quite enjoyed playing around in. However, it is far from perfect, as becomes clear in Section 6.7.4, which discusses potential improvements for a future version.

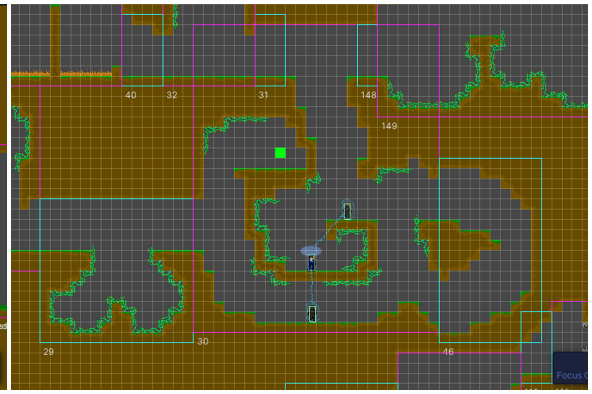
### 6.7.4 Future improvements

Although the level generation algorithm was sufficient and arguably even too proficient for the simple tasks asked of it during the experiment. Throughout the development of the case study game, I considered the game as a product, rather than merely a means to evaluate the design strategy. As such, I thought a lot about the ways in which it could be improved, even if those methods went beyond the scope of this project. This section lists some of the changes that I would personally like to see applied to the level generation algorithm if it was to be redesigned for a future project.

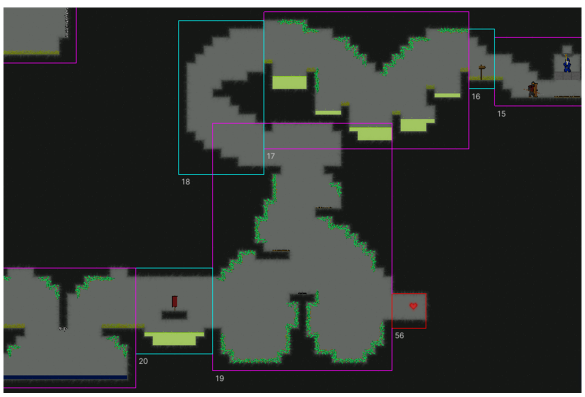
Firstly, in hindsight, the distinction between Primary and Filler Areas seems redundant. Currently, the only real differences are that Filler Areas must have exactly 2 connection points and are generally smaller and emptier compared to Primary Areas. However, this division is not really necessary and only really adds unnecessary complexity to the algorithm.



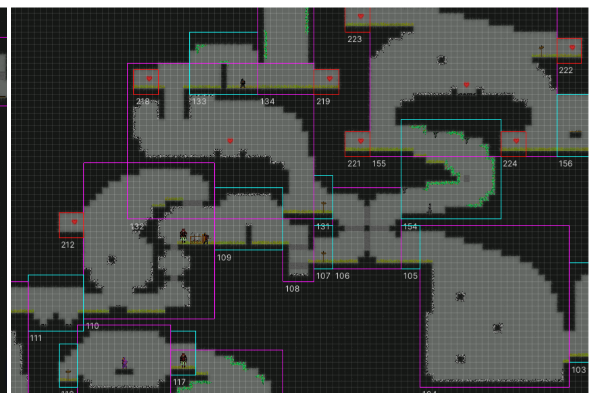
Example 1: The enemy in the bottom of the image patrols through 4 different areas.



Example 2: The center area (30) connects with 4 different areas (29, 31, 46, and 148). Area 46 even creates a loop that makes it feel like a mere extension of the center area.



Example 3: Area 19 overlaps closely with Area 17, making the level appear more dense and interconnected. Without allowing this overlap, this area could not have spawned here.



Example 4: Here, Area 106 serves as a central hub, connecting to areas 105, 107, 131, and 154. Each of these connections leads to long paths, often overlapping with other areas. This makes the world feel dense and interconnected, and regularly creates situations such as those described in examples 1-3.

Table 6: Some examples of ways in which the level generation algorithm can create interesting geometry and gameplay scenarios. Note that the images can be clicked to view them in enhanced quality.

Another recommended adjustment is to alter the way the level length is calculated. Currently, the level length is based on the number of Primary Areas placed. However, Primary Areas can differ significantly in size, meaning that levels of vastly different lengths could be generated using the same level length value. An example of a better solution would be to calculate the 'playable area' of each HCA (all the tiles that are not ground or hazard) and use that instead.

Another point that influenced the design of certain HCAs is that players need to be able to traverse them in any direction. The algorithm doesn't know whether the player is travelling from connection point A to connection point B or vise versa. Adding teleporters (e.g. like the teleportation monoliths in Dead Cells) could allow for the inclusion of some more unique HCAs without fundamental adjustments to the level generation algorithm.

Currently, the spawning chance of every area is the same[28]. Ideally, each HCA should have extra parameters that enable factors like its difficulty, visual distinctiveness, and the level in which it is placed to also be factored in. Additionally, some areas are very similar, yet occupy distinct places in the array, making them more likely to be picked. Giving the HCAs that are visually or mechanically similar a certain identifier can help prevent them from spawning close together and making the level appear more repetitive. Giving each HCA a maximum number of times they can spawn in any level would also help to prevent repetition of some very visually distinct areas.

Additionally, the original plan was to be able to use the same areas for different levels using reskins (see Table 7). Adding small changes to reused assets helps make them less noticeable or boring to the players [NS13]. However, changing sprites, hazards, and enemies can only go so far in making believable and immersive levels. Certain types of geometry are simply more suited for certain environments (e.g. Cave level geometry vs castle level geometry), and adjusting the probabilities that a certain HCA gets selected based on the level it will be placed in could help to ensure that each level is visually and mechanically unique.

Lastly, the addition of more areas of all types, as well as the inclusion of a level editor that allows players to create their own HCAs, could lead to more unique, distinct, and replayable levels. A simple addition that could potentially increase the perceived number of unique HCAs significantly is to give the level generation algorithm the ability to horizontally mirror existing HCAs.

[28]Not exactly, some areas are harder to place due to their size, the number of connection points, and the placement of said points. While these areas are equally likely to be selected, their placement may be invalidated more often.

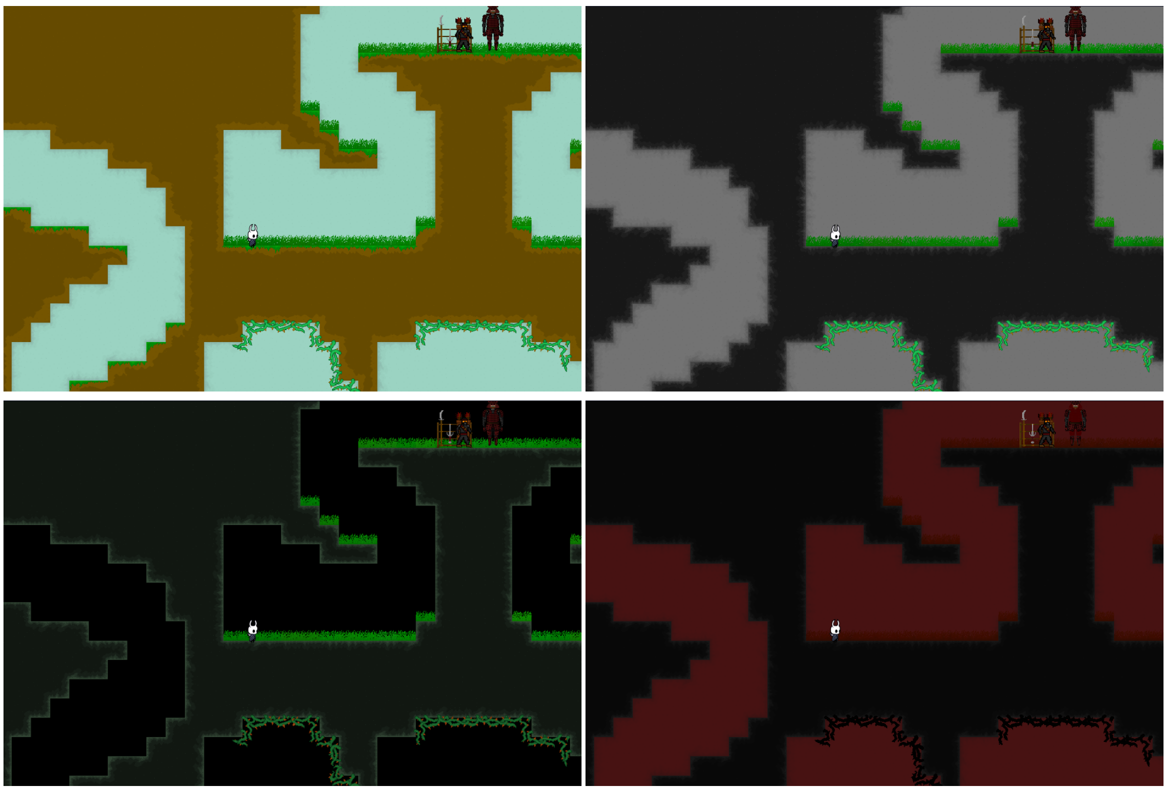


Table 7: Examples of how levels could potentially be reskinned to make different levels feel visually distinct. Note that the implementation of this feature has remained rather limited, and as such, these examples do not contain all the planned adjustments (e.g. different tilesets, enemy and hazard spawning probabilities, and level-dependent spawn probabilities of different HCAs). Please note that the player character was still a placeholder at this point in development (the knight from Hollow Knight).

## 6.8 Difficulty

The concept of difficulty is present in all videogames, regardless of genre, and serves as the catalyst for challenge [NS42]. Game challenge is discussed in Section 7.1, but to briefly summarize: Challenge is associated with a player's perceptions of difficulty within a gaming context [52]. It is a key factor for engaging gameplay [154, 153], important contributor to immersion [124], antecedent to flow [4], and plays a crucial part in a game's ability to motivate players [148, 45, 112, 75, 26][NS40].

A game's difficulty and the enjoyment of said game have an almost inseparable relationship. Although enjoyment is a highly personal and subjective experience, the difficulty system of a game is one of the main objective factors through which developers have a direct effect on individual players' experiences [NS42]. It's imperative that game developers find the right challenge-skill balance in order to provide an enjoyable and engaging yet challenging experience [236, 32][NS42, NS30]. This balancing process is both extremely subjective and intricate and is entirely dependent on the needs of the game and the experience developers wish to convey [NS42].

### 6.8.1 Hero fantasy

Many games offer the promise of letting the player live out some fantasy (e.g. being a race car driver, rock star, or assassin), which has a great influence on the enjoyment of the game [NS63]. When taking difficulty into consideration, 2 distinct methods of delivering this experience arise: Games can either give the fantasy for free, or make the player earn it through mastery of the game's mechanics [NS63].

Games can use tricks such as translating simple inputs into flashy animations, lenient systems that subtly correct for small mistakes (like the ones discussed in Section 6.5.2), programming enemy AI not to attack all at once or from outside the player's field of view, hidden stats (e.g. giving the last few bullets extra damage in Gears of War), etc., as well as providing an overall low(er) difficulty level. All these tricks can help give the player the sensation of being powerful [NS63]. In other games, this experience is withheld until players have proven themselves to have mastered the game's mechanics. Table 8 summarizes the main advantages and disadvantages of each design philosophy.

| | **Give hero fantasy** | **Earn hero fantasy** |
|---|---|---|
| Example games | • Batman: Arkham City<br>• Assassin's Creed Odyssey<br>• Spider-Man | • Doom Eternal<br>• Dark Souls<br>• XCOM<br>• Hollow Knight |
| Advantages | • Accessible for players of all skill levels<br>• Instant gratification<br>• Wider target audience | • Attainment of the fantasy / mastery of the mechanics is far more satisfying and meaningful<br>• Smaller but more dedicated playerbase |
| Disadvantages | • Can end up feeling shallow or even patronizing to more experienced gamers<br>• Victories feel less meaningful | • Mastery can sometimes be unattainable by less skilled players, leading to a smaller playerbase overall |

Table 8: The primary advantages and disadvantages of both main philosophies for delivering the hero fantasy to players.

It's important to note that games of both high and low difficulties can and have succeeded in providing enjoyable experiences to their respective player bases [NS42]. It's also important to note that the 2 methods of implementing difficulty as described above aren't the sole factors that determine the difficulty of the final product. Genre, accessibility options, multiplayer options, offering multiple ways to tackle challenges, the punishment for failure / dying, and many more aspects of a game all factor in to determine the overall difficulty.

On top of this, some game developers have taken to using Dynamic Difficulty Adjustment (DDA), as opposed to the more traditional Static Game Difficulty (SGD)[29]. Whereas SGD refers to a certain level of difficulty that persists throughout the whole game (regardless if this is easy or hard), DDA is a system within a game's design that will, often discreetly, adjust certain factors within the game in response to user actions in real-time, in order to tailor the difficulty to the player's individual needs [169][NS42, NS36]. Although I would have liked to include some form of DDA in the case study game, due to the limited development time available, the game exclusively uses SGD in its current state.

[29] Games that incorporate difficulty modes (e.g. 'Easy', 'Medium', 'Hard') are still considered to have static difficulty.

### 6.8.2 Difficulty of the case study game

The philosophy behind the design of difficulty in the case study game is to make the players earn the hero fantasy, meaning that the difficulty of the game will be on the higher end of the spectrum. Aside from the arguments listed in Table 8, which did factor in heavily, there are some other reasons for this decision that are more specific to the case study game.

One reason for making the game more difficult is to encourage exploration. High difficulty can encourage exploration since the players are more motivated to collect every available resource / tool that can help them [NS61]. Naturally, the difficulty of levels should gradually increase as the player progresses through the game [22, 245][NS48]. However, since the case study game is a roguelike (see Section 6.2.2), it is meant to be completed in a single run. This means that the players will have had much more practice and experience with earlier levels compared to the later levels. They're likely to need additional resources in the later levels to compensate for this inexperience, as well as to deal with the ever-increasing difficulty of the levels, meaning that they're encouraged to explore and collect all available resources in the level, practicing their skills as they do so. The typical high initial difficulty of roguelikes means that this process of collecting resources and upgrades (within a single run, as well as over multiple playthroughs) can keep the game interesting and replayable for a long time [NS40].

The second argument also relates to replayability. As discussed in Section 5.3, in order to maximize its replayability, the case study game does not focus on graphics, story, or puzzles, but rather on engaging and enjoyable moment-to-moment gameplay. Prensky [198] defines gameplay as "all the activities and strategies game designers employ to get and keep the player engaged and motivated to complete each level and an entire game", and states that it is one of the foremost characteristics of a good game. Good gameplay originates from the continual decision making and action that engages the player and keeps them motivated to continue [129]. There are two aspects of gameplay: engaging users moment by moment, and relating current game actions to future objectives (e.g. unlocking permanent upgrades) [129]. In good moment-to-moment gameplay, each in-game action or decision tends to naturally lead to the next one, putting the player in a psychological state of flow [57]. It's my intention that the same thing should happen whilst engaging in combat or platforming challenges in the case study game.

Difficulty factors in here as well. Firstly, a proper level of challenge is required for the player to enter a flow state [4, 196][NS42, NS30]. Secondly, higher difficulty typically means that it will, on average, take players longer to fully master the game mechanics, extending the overall time that players engage with the game. Once players have fully mastered the mechanics of a game, it can quickly lose its appeal, as there is nothing new to learn [33]. Games are commonly designed to put challenges to reach outcomes, and the process of achieving these outcomes is typically the most rewarding aspect, even more so than the outcomes themselves [170, 141]. Higher difficulty enhances the duration of this process and thus the replayability of the game.

Then there are genre conventions. Roguelikes tend to be rather difficult, which has sometimes proven to be a drawback for more casual players [33]. Genre conventions like this can help manage players' expectations about a game [29][NS53], so that the high difficulty does not come as a surprise. Priming players for failure by never suggesting that the game will be easy can help maintain a more positive player attitude in the face of adversity [NS63][30]. Failures do not necessarily impair the enjoyment of a game if a reasonable amount of practice or trying a different approach enables the player to overcome the obstacles that they previously failed to tackle [88].

Lastly, although high difficulty can deter some players, it can also enhance the experience for others. Whilst enjoyment is often perceived as the paramount purpose of videogames, and, as such, other aspects of the game should work strictly in favor of player enjoyment, in some cases a higher difficulty is essential to attain a game's desired effect [NS42]. The consequence of this is usually that the player base will be reduced to only those able and willing to gain mastery within the game itself, and although this decision may initially hinder the enjoyment of a portion of the potential playerbase, it heightens the enjoyment for those able to succeed within the game in return [NS42].

XCOM is a good example of this principle in practice. In his 2017 GDC talk, Justin Fischer attributed XCOM's success to their uncompromising stance regarding the game's difficulty, stating how "It served the intended audience very well and it didn't make any compromises to dilute the experience for that target segment" [NS8]. This philosophy eventually led to critical acclaim and a dedicated and passionate playerbase.

On a final note, it's also important to implement and use difficulty correctly in order to prevent the game from being perceived as unfair. The difficulty should be placed on the skills of the player, and not on things like confusing or unfair level design [245][NS48]. However, when a game is clear about the inner workings and limits of its mechanics, developers can make it as difficult as they want without it feeling unfair [NS17].

[30] This can be done in a lot more ways than just following genre conventions (e.g. In-game narrative, marketing, etc.)

### 6.8.3 Enemies & hazards

Different types of enemies and hazards can drastically change the difficulty and pacing of a game [245], and as such, form the primary source of challenge in the case study game. Engaging in combat and traversing hazardous terrain puts the player's skill up against the risk of losing lives. This section discusses the different types of enemies and hazards in the game and their roles in gameplay. Table 9 lists the different enemy types and Table 10 shows the different environmental hazards.

| | |
|---|---|
| <br>**Shuriken Thrower** | Shuriken throwers patrol an area by walking side to side, pausing on each side to look around. If they spot the player, they'll attack them by throwing shuriken stars at them. They can jump backward in defense if the player approaches them.<br><br>The shuriken stars can be deflected back to the enemy by the player. They can also be used to spike jump. Shuriken stars that miss will stick into walls, where they can still damage the player or be used to spike jump until they despawn after a certain time.<br><br>Typically, enemies in games have individual difficulty (i.e. how difficult are they to fight alone), and can become more difficult when combined with other enemies or hazards [245]. The shuriken thrower alone isn't too much of a threat, but its ability to attack the player from afar whilst the player has to deal with other enemies can create challenging situations. |
| <br>**Shielded Enemy** | Shielded enemies cannot be hit from the front. Instead, the best method of defeating them is to bait out an attack and counter from above or behind them.<br><br>If the player is close to them, they'll attack with their spear. If the player is further away, they can charge forward with their shield. They're not easy to push off edges and serve as a sort of tank, focussing primarily on area denial.<br><br>Although they're a bit more challenging that some other enemies individually due to their shield, the level of challenge is mainly determined by the context within which they are fought. E.g. the difficulty is significantly increased when the geometry does not leave sufficient room to jump over the enemy. |
| <br>**Sai Hunter** | Sai hunters' primary objective is to put pressure on the player. Contrary to the Shuriken thrower and Shielded enemy, who cannot travel vertically, and can therefore be engaged with at the player's leisure, the sai hunter is able to chase the player. If the player were to flee to a different platform, the sai hunter is able to teleport after them. This also means that once a sai hunter has spotted the player, they will never lose aggro; They'll chase the player until they're defeated.<br><br>This can be used to create interesting scenarios. For example: players can lure sai hunters into a more comfortable combat space (e.g. lure them away from a protector wizard), or even lure them into traps. This change in combat space can help to make combat feel more varied and less static [245]. |

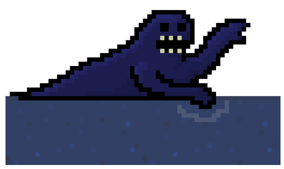
| | |
|---|---|
| <br>**Protector Wizard** | Like the name suggests, the protector wizards do not attack the player directly. Instead, they generate a shield that protects all nearby enemies from taking damage. They have very little health themselves, and are defeated by a single attack. The challenge is determined by how difficult it is to reach the protector wizard.<br><br>This creates a prioritization challenge for the player, as the protector wizards must be defeated first, but it might not be the enemy in the closest proximity to the player. Posing small, immediate choices such as these make a level more replayable [245].<br><br>Protector wizards can also be used to create interesting gameplay scenarios. For example: A big pit of acid with shuriken throwers in the acid. Normally, the acid will kill enemies, but not if they're protected by the wizard. The player must pass through a barrage of shuriken stars but can then defeat all enemies by striking a single, satisfying blow to the protector wizard. |
| <br>**Sludge Monster** | Sludge monsters border the line between enemy and environmental hazard as they only spawn in pits of blue sludge. This sludge hampers the player's movement, making them move slower and jump less high. This forces the player to engage with the continuously spawning sludge monsters. The sludge monsters don't have a lot of health, but they're faster than the player, forcing them to make the choice to either fight them, jump over them, or take damage.<br><br>The sludge monsters are unique in that they spawn continuously, so they can never truly be defeated. This, in combination with the encumbered player movement in the sludge, means that the sludge pits are never a preferred combat space. Forcing the player into an awkward spot such as a pit full of sludge can create interesting combat scenarios. It is also possible to make the surrounding walls around the pit too high for the player to reach, forcing them to use the sludge monsters to spikejump on to escape. |

Table 9: The different types of enemies in the game.

Given more time, I would have liked to incorporate more enemy types and hazards into the game. Enemies like rats, kamikaze birds (e.g. Kamikaze from Dead Cells, Belfly from Hollow Knight), bomb throwers (e.g. Grenadier and Bombardier from Dead Cells), enemies that hide underground and jump out (e.g. Sewer's Tentacle from Dead Cells, Dirt Divers from Blasphemous), archers (e.g. Predator character from Broforce), large enemies that are capable of destroying parts of their surroundings (e.g. GR666 from Broforce), or monks that fight with karate chops and kicks are all capable of filling a certain role in the game and posing their own unique challenge, as well as being used in conjunction with each other in interesting ways. There was initially even a plan to include a boss fight with a sumo wrestler, dragon, or demon.

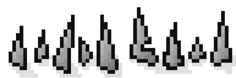
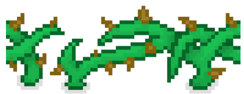
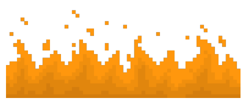
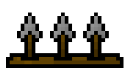
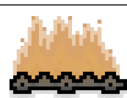
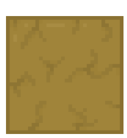
| | |
|---|---|
|  **Spikes** (Static environmental hazard) | Spikes are a common static environmental hazard that can be found on the floor, on walls, and on the ceiling. Although touching them will damage both the player as well as the enemies, spikes also offer the player the option to spikejump. |
|  **Thorns** (Static environmental hazard) | Thorns are another common static environmental hazard that can be found on the floor, on walls, and on the ceiling. Aside from the visual difference with spikes, the primary difference is that thorns cannot be used to spikejump, meaning that they should only ever be avoided. |
|  **Acid** (Static environmental hazard) | Acid can only be found on the ground, and damages anything that touches it. It can not be used to spikejump. |
|  **Fire** (Static environmental hazard) | Fire has the exact same characteristics and functionality as acid, and essentially only serves as a reskin of the acid tile that is meant to create more visual and aesthetical diversity. The only note is that although acid needs to be surrounded by ground tiles to each side, fire only requires a ground tile below[31]. |
|  **Spike trap** (Dynamic environmental hazard) | The spike trap is a dynamic trap that triggers when the player walks over it. After a short timer (0.75 seconds), spikes will shoot out that can damage both player and enemies. These can also be used to spike-jump. The spikes will automatically retract after 2 seconds. |
|  **Fire trap** (Dynamic environmental hazard) | The fire trap functions almost identically to the spike trap mechanically, the main difference being that it cannot be used to spikejump since it shoots fire. In addition, the burst of flames is only active for about 1 second, rather than 2. |
|  **Falling stalactite** (Dynamic environmental hazard) | Falling stalactites are especially common in cave area levels. If the player walks under them, they will crumble and fall down. They're capable of damaging both the player as well as enemies. The player also can hit them to destroy them (before, during, or after they fall), and they can even be used to spikejump, albeit only once. |
|  **Destructible sand tile** (Dynamic geometry tile) | Destructible sand tiles function similarly to regular ground tiles, but since they will crumble if the player walks on them, they only offer temporary safety (0.95 seconds). Disappearing (or falling) platforms are a common trope in platform design, as they're an easy method of giving the players a time limit for their next action [NS18]. The player can also hit these tiles to destroy them instantly. Enemies are able to walk on these tiles. The tiles respawn after 5 seconds. |

Table 10: The different environmental hazards in the game.

In terms of environmental hazards, I also created an exploding crate, but this remains unused since there was insufficient time to fully program its functionality. Hazards that automatically occur periodically (e.g. periodically erupting volcano / geyser, periodically dripping acid (e.g. like those in the Desecrated Cistern area in Blasphemous). Surfaces that are more slippery or sticky, walls that cannot be climbed on, or environmental forces like wind also never made it into the final product.

The exclusion of these assets is mainly due to the limited time available for the development of the game. Asset creation is a very time-consuming process, and it made more sense for me to create a few enemies that each serve a clear role in combat instead.

## 6.9 Excluded features

Throughout the development process of the case study game, I've treated it like an actual product that's intended for production, rather than just a means to evaluate the proposed design strategy. This means that the game is designed around certain features that do not influence the results of the experiment (e.g. the permanent upgrades across playthroughs discussed in Section 6.6.1, or the adjustable pacing mentioned in Section 5.4). These types of features did not make it into the final product. Things like the improvements to the level generation algorithm discussed in Section 6.7.4 and the addition of more enemy and hazard types discussed in Section 6.8.3 are also not present in the game in its current state. These features / additions are largely outside of the scope of this project, and were not required in order to execute the experiment. However, there are some aspects of the game that were excluded or left unfinished because of different reasons.

First, there is the overall lack of polish. The game does not make a lot of use of VFX effects such as particles[32], does not use any post-processing, and effects such as camera shake or controller vibration, as described in Section 6.5, aren't yet applied to their fullest potential. Although effort was made to make the game stand out by using an unique aesthetic, utilizing an artstyle that's relatively easy to create a lot of assets with, and having a clear focus on gameplay over aesthetics, there is still a notable lack of polish to the game that should be addressed if the game were to become an actual product.

Most of the accessibility considerations discussed in Section 5.2 are also not present in the game in its current state. Throughout the development process of the game, accessibility considerations were always in the back of my mind,

[31] Both acid and fire can stack on top of each other (I.e. it is possible to make acid or fire pits that are more than 1 tile deep), the only requirement is that there is a ground tile under it at some point.

[32] There are particle effects present in the game though (e.g. dust when running or jumping, blood particles when hitting enemies, sparks when hitting steel, flying grass strands when grass is cut, sparks and smoke around fire and fire traps, etc.).

and the gameplay is designed so that they could actually be implemented with relative ease, and to some extent they already are (e.g. hazards have distinctive shapes, color, and sometimes movement, making them easy to identify even for people with visual impairments such as colorblindness). Regardless, the high degree of customizability and the majority of the functionalities that could enhance the case study game's accessibility aren't present in the game in its current state. The primary reason for this is that these components were not required in order to perform the experiment.

Lastly, there isn't any audio in the game. Throughout the development process, I have challenged myself to step outside of my comfort zone as a programmer / game designer and also dabble in other aspects of game development such as asset creation and audio design. However, I did not consider the audio to be a priority and only started working on it towards the end of the development, and although there was still sufficient time remaining to implement the audio, it was ultimately my (lack of) skill that led me to discard audio altogether. Since poor sound quality or audio design is more likely to distract the player, rather than to help them be immersed and engaged with the game [49, 226], and I was unable to reach a satisfactory level of quality, I chose to abandon audio altogether.

This also affects the accessibility considerations described above, as one of the easiest ways that developers can enhance the accessibility of their game is to communicate things through multiple channels (e.g. warn players of an incoming attack via visual and auditory clues)[244][NS65]. Without the use of audio, one of these channels is closed, limiting the ways in which this multichannel approach can be implemented and also preventing it from occurring naturally, without explicit developer intent. If the game was to become an actual product, the lack of audio should be addressed.

# 7 Preparing experiment

As stated in Section 4, the new design strategy for serious games that is proposed in this report will be evaluated via a case study game. However, before this is possible, the criteria by which the case study game will be judged, as well as the method used for measuring these criteria, must first be defined.

## 7.1 Defining fun in videogames

The terms ‘fun’, ‘entertainment value’, and ‘enjoyment’ have been used throughout this report but have remained vaguely defined. These are attributes of a videogame that refer to how much people enjoy interacting with it; the so-called ‘gaming experience’ (or ‘player experience’). Terms like fun, flow, presence, immersion, and playability are often used to describe gaming experience [25, 35]. At its simplest level, the term ‘gaming experience’ concerns the player’s one-to-one relationship with the game [85]. It is difficult to define and measure what a gaming experience exactly is, as it does not comprise of a single experience, but numerous, although flow, immersion, affect, challenge, and the development of skills appear to be central elements [106, 169].

The increasing popularity of games is reflected in a vast and expanding field of research [178, 149, 93, 170], which includes researching what makes a game provide the best experience for the player [63]. Moizer et al. [169] emphasized the need for understanding user experience for serious games specifically. Consequently, the number of scientific contributions on game evaluation has grown steadily during the past decade(s) [25][33]. But despite the now relatively high number of methods used to evaluate user experience and related concepts, a general framework for evaluating the various interaction concepts used in game design is lacking; there is no common agreement regarding what kind of (usability evaluation) methods can be used to enhance game design [25, 194].

As such, subjective metrics such as fun, engagement, and enjoyment rely mainly on questionnaires and open questions that allow participants to self-report their feelings and perceptions of an activity or experience [171]. Questionnaires are a popular and useful research method because they are simple to use and also provide certain standardization [171]. Questionnaires are capable of evaluating the most diverse emotions and feelings a person might have (e.g. Subjective Happiness Scale (SHS), Psychological General Well-being Index (PGWBI), Profile of Mood State (POMS), among others [220]) [171].

A game’s ‘playability’ is a common feature when evaluating the quality of computer games [170]. Yet, agreement on the exact definition of playability is lacking [170]. Sánchez et al. [221] define playability as “the set of properties to describe the player’s experience with a particular game system, that the principal goal is fun/entertainment to the player in a satisfactory and credible way,

[33]This paper was published in 2007, but the number of scientific contributions has continued to grow since.

playing alone or with other players. Playability reflects the player's pleasure, experience, sensations, and feelings when he/she is playing the videogame". Another source [NS34] defined playability as "the degree to which a game is fun to play and usable, with an emphasis on the interaction style and plot-quality of the game; the quality of gameplay. Playability is affected by the quality of the storyline, responsiveness, pace, usability, customizability, control, intensity of interaction, intricacy, and strategy, as well as the degree of realism and the quality of graphics and sound". Following these definitions, playability seems like an abstract feature that is the result of several characteristics of a game.

However, there are definitions that stray further, like that of Engl [70], who defines playability as "the degree to which all functional and structural elements of a game (hardware and software) enable a positive player experience to the gamer". This definition considers playability more as a prerequisite for a positive player experience, in a similar manner as usability can be considered a prerequisite of user satisfaction, or as a technical and structural basis for the player experience, but not the player experience itself [170]. This is in line with Järvinen et al. [120]'s notion of functional playability, which states that (serious) games must, above all else, be usable in order for users to have a positive gaming experience. Characteristics of usability include the ease of use of the interface, user control within the gaming environment, avoidance of errors, and satisfaction with the game's interactive features [109].

Functional playability, as described above, is very similar to a feature called playing quality, which can be considered as a sort of 'game usability' [170]. Pinelle et al. [193] defines playing quality as "the degree to which a player is able to learn, control, and understand a game. [...] Game usability does not address issues of entertainment, engagement, and storyline, which are strongly tied to both artistic issues (e.g. voice acting, writing, artwork, and music) and technical issues (graphic and audio quality, performance issues)". However, as Möller et al. [170] points out, the definition of usability is based on the concepts of effectiveness and efficiency, and defining these concepts within a gaming context has proved much more difficult, since it is usually the task of the game to spend resources of the user. This is the distinction between 'playing quality' and 'game usability'.

The gaming experience itself is a broad concept that covers a large set of sub-aspects [170]. The concept was briefly introduced at the beginning of this section but since it is an encompassing term that essentially reflects the exact characteristics this (case) study intents to measure, it is worth it to further define this term. Poels et al. [194] defined gaming experience[34] as the accumulation of 8 sub-aspects; challenge, control, tension, flow, immersion, competence, positive affect, and negative affect. The remainder of this section is dedicated to discussing each sub-aspect of the gaming experience.

[34]Their original definition is of 'player experience' within a gaming context. This report considers 'player experience within a gaming context' and 'gaming experience' as synonyms.

- **Challenge** is an attribute of the gaming experience associated with a player's perceptions of difficulty where their physical and/ or cognitive abilities are challenged within a gaming context [52]. Malone [154, 153] argues that challenge is one of the key qualitative factors for engaging gameplay. In order to provide challenge within a game, it must provide goals whose attainment is uncertain [155][35]. This uncertainty can originate from multiple factors; variable level difficulty, providing multiple goals or levels of challenge (e.g. complete the level or complete the level without being spotted), hidden information, or randomness [152]. Challenge is an important contributor to immersion [124], as well as an antecedent to flow [4], which encourages learning [126]. Several authors argue the link between appropriate levels of challenge within games and their ability to motivate users to engage with them to potentially develop (new) skills [148, 45, 112, 75, 26]. As player skill improves, the level of challenge offered by the game should increase as well [22]. The design of the challenge / difficulty in the case study game and the reasoning behind this design are discussed in Section 6.8.

- **Control** refers to the autonomy a player has in their abilities to control, alter, explore, or interact with the virtual environment, execute actions, and generally just adjust the game to their liking. It essentially refers to the freedom that a player has to adjust the virtual world to their preferred state. This also includes things such as adjusting the settings of the game. Breuer et al. [32] lists the specific mode of interactivity that videogames offer as a crucial reason for their attractiveness and argues that this interactivity happens on 3 distinct levels; the micro-level (e.g. you push a button and the player character moves), the narrative level (e.g. interacting with NPCs and progressing through a game to learn how the story unfolds), and the meta-level of setting and manipulating the game's rules (e.g. choosing difficulty levels, using mods or cheats). A common feature across all 3 levels of interaction is that they give the player a feeling of self-efficacy [257, 16]. Players experience that their own actions are effective within the virtual game world, and this sense of control is considered pleasurable and motivates further interaction [32].

  Just like challenge, control is a double-edged sword, and getting it just right is important. Giving the player too many options can make it more difficult to control the pacing and flow of the game, whilst giving the player too few choices can make the game feel linear and dull [245]. The conflict between designers' authorial control to maintain certain qualities of the gaming experience and players' agency to explore and interact with the world as they wish is known as the "narrative paradox", and is a key challenge in the design of videogames, especially narrative-centric ones [13]. Generally, the more freedom a player has to influence the virtual world,

[35] If a game doesn't provide a goal, but is rather something that can just be played, it is called a 'toy', although grey areas such as simulation- or sandbox games exist [196].

the stronger their feeling of agency. Yet, this can also potentially make it more difficult for designers to control the quality of the in-game narrative, its coherence, and dramatic arc [258], as well as other aspects of the game such as the learning curve. These downsides mainly arise during gameplay and level design - giving the player the ability to adjust the settings of the game is generally a good thing [NS56].

- **Tension**, as experienced within a gaming context, can lead to emotions such as excitement, frustration, irritation, disappointment, or anger [236, 194]. Although tension can lead to negative affects, which is something game designers and facilitators generally seek to avoid [219], negative experiences such as in-game frustration or tension are presumed to be essential for the overall gaming experience to work [92, 194]. Tension is an important component of game enjoyment [136][36], and an antecedent for game engagement [259].

- **Flow** theory was first proposed by Csikszentmihalyi, who states that flow is an equilibrium between boredom and fear, between requirements and abilities, and it is a dynamic experience of complete dissolution of an acting person in his/her activity [55]. Games can induce a flow state when the challenges they pose to the player match the player's abilities, and doing so correctly is a key challenge in game design [196, 129]. When playing a game, players want to be challenged, control what surrounds them, develop a sense of mastership and achievement, and be rewarded consequently [53, 153, 154, 156, 212, 213]. Gee [87] argues that the gaming experience should be "pleasantly frustrating"; a challenge for the player, but not an insurmountable one.

  Flow is derived from fulfilling the need for competence [107]. In continuation of this principle, Power et al. [195] introduced the concept of 'mastery experience'; the feelings within a player when they receive positive feedback as an outcome for a task that they completed [NS42].

  Flow is generally considered a positive experience [107] and, as such, well-designed games are likely to promote this state of mind [250]. Successfully motivating a flow state within the players during gameplay heightens their perception and enjoyment of the game, creating a more positive gaming experience overall [NS42]. Murphy [177] related the term fun directly to flow, stating that fun is "the positive feelings that occur before, during, and after a compelling flow experience". Intrinsic motivation is important for flow, but can also arise from it, which, in turn, can help to promote immersive learning [48, 186]. The role of challenge, and, by proxy, flow, is not limited to a gaming context, but has been noted by motivation researchers as relevant to all learning activities [144].

[36] This source uses the term 'suspense' rather than 'tension', but proceeds to list tension as an experience that typically involves suspense.

- **Immersion** is the degree to which a player feels integrated within another (virtual) reality, and, inversely, the degree with which the perception of the real world reduces [170, 240]. Immersion contributes to the engagement and enjoyment of a game [35, 161], improves the overall gaming experience [106], and has been identified as an important criterion to enhance the effectiveness of serious games [17].

  Taylor [240] subdivided immersion into 2 distinct types. The first type is diegetic immersion, where the player is immersed in the act of playing the videogame in a similar way as a reader would become engrossed in a novel, or a viewer in a film. The second type of immersion is called intra-diegetic (or situated immersion), which corresponds to immersion within the created virtual space in the game situated through both the character's perspective and an embodied point of view [240]. In a gaming context, the attributes of a game can create the illusion that the player is actually in the space of the diegesis, whereas this is a primarily figural notion — a conceit of narrative convention — in other modes of spacial representation like film [240]. Highlighting this distinction is important, as researchers seem to have the habit of focussing on one type of immersion and simply using the term 'immersion'.

- **Competence** is the counterpart to challenge, which, when balanced properly, creates flow. Law and Sun [140] define gaming competence as the ability to perform tasks or actions within the game successfully. A player's competence can be linked to their self-efficacy through their ability to master and control a game [86].

  Psychological constructs like player competence, the corresponding need for challenge, or in-game autonomy are important factors for maintaining motivation [22, 112, 218]. Fantasy, which is claimed to have both cognitive and emotional benefits in the design of instructional environments, can also heavily depend on player competence [155][37]. Additionally, a player's competence is of great influence on maintaining the hero/power fantasy within a game [NS63]. Player competence can sometimes be related to other aspects of a game that can influence the overall experience (e.g. skill-based match making in Call of Duty: Warzone) [112].

  The most engaging games are those that hover around the borders of a player's competencies [32][NS30]. If a player's skills are not competent enough to meet the active challenges set within a game, players may experience anxiety. Likewise, they can be bored if the challenge is set too low [202].

- **Positive and negative affect** relate to a game's ability to induce emotions within its players [169, 26]. It has been suggested that some of the most intense positive emotional experiences are triggered within a gaming

[37] This paper distinguishes extrinsic fantasy, which only slightly depends on the player's skills, and intrinsic fantasy, which is intimately related to the player's skills.

context [159]. Granic et al. [99] claims that gaming may be among the most efficient and effective means by which children and youth generate positive feelings, and several studies have indicated the causal relation between playing preferred games and improved mood or increased positive emotions (e.g. [215, 218]).

There are numerous methods that games can use to invoke emotions. One of the most common forms is the measuring of player progress against the goals set within the game (e.g. win / lose, achievements, highscores, etc.), which have strong emotional and ego-gratification implications that are a big part of the attraction of games overall [196]. But other elements within a game such as color, lighting, music, atmosphere, story, interaction with others, or even the type of input device used to control the game can influence a player's emotional state [245, 189].

## 7.2 Measuring fun in videogames

Section 7.1 defined the explicit concept that is to be measured in this study; the gaming experience, and proceeded to state that subjective metrics like this mainly rely on questionnaires to be quantifiable [171][38]. Questionnaires are also simple to use and provide a certain level of standardization [171]. As such, the experiment performed to evaluate the gaming experience of the case study game, and, by extension, the design strategy as a whole, will also make use of questionnaires. The remainder of this section will be dedicated to the discussion of different questionnaires that are often associated with the evaluation of videogames and determining which one is best suited for my experiment, using the selection of Nordin et al. [182] as a starting point. Table 11 lists the different types of questionnaires and summarizes their primary components.

[38] Please note that questionnaires are not the only method with which such metrics can be evaluated. This same study [171] proceeds to attempt to evaluate engagement using EEG

| Questionnaire | Components |
|---|---|
| Immersive Experience Questionnaire (IEQ) [124] | • Emotional involvement<br>• Cognitive involvement<br>• Real world dissociation<br>• Control<br>• Challenge |
| Game Engagement Questionnaire [34] | • Flow<br>• Absorption<br>• Presence<br>• Immersion |
| Player Experience of Need Satisfaction (PENS) [218] | • Competence<br>• Autonomy<br>• Relatedness<br>• Presence (immersion)<br>• Intuitive controls |
| Flow Questionnaire [56] | • Clear goals<br>• High concentration<br>• Reduced self-consciousness<br>• Distorted sense of time<br>• Direct and instant feedback<br>• Balance between level of ability and challenge<br>• Sense of personal control<br>• Intrinsically rewarding activity |
| GameFlow Questionnaire [236] | • Concentration<br>• Sense of challenge<br>• Player skill<br>• Clear goals<br>• Control<br>• Feedback<br>• Immersion<br>• Social interaction |
| Presence Questionnaire [260] | • Control factor<br>• Sensory factor<br>• Realism factor<br>• Distraction |
| Social Presence in Gaming Questionnaire (SPGQ) [60] | • Behavioral engagement<br>• Psychological involvement<br>– Empathy<br>– Negative feelings |
| Simulator Sickness Questionnaire (SSQ) [131] | • Nausea<br>• Oculomotor<br>• Disorientation |
| Game Experience Questionnaire (GEQ) [116] | • Challenge<br>• Control<br>• Tension<br>• Flow<br>• Immersion<br>• Competence<br>• Positive and negative affect |

Table 11: Different questionnaires commonly used in the evaluation of gaming experience and their respective components.

The Immersive Experience Questionnaire [124] is widely used in determining the levels of immersion experienced by players in a videogame [182, 171]. It has been tested across a far-reaching array of different scenarios and game types (e.g. [52, 222, 241]), and has even been adapted for film and TV [207]. The IEQ uses five-point Likert scale questions, phrased both positively and negatively, for measuring player experience, but is specifically focused on the notion of immersion in gaming [182]. Although this questionnaire is a promising contender, the focus on immersion makes it less suited for this experiment, as this experiment aims to evaluate the gaming experience as a whole.

The Game Engagement Questionnaire [34] was originally developed to assess the impact of (deep) engagement in violent videogames, and has many similarities with the IEQ [182]. The questionnaire consists of 19 questions that are answered using a five-point Likert scale. Unlike the IEQ, all questions are phrased positively, and as such, the higher the score that the participant gives for each question, the more engaged they are considered to be. The approach to engagement as a single dimension (ranging from immersion to flow) means that this questionnaire is also unable to evaluate the entire gaming experience. Additionally, there is relatively little empirical validation undertaken to establish the reliability of this questionnaire [182][39], and the singular focus on violent videogames and aggressive behaviour has also received criticism [183].

The Player Experience of Need Satisfaction model is derived from the well-established theory of motivation; Self-Determination Theory (SDT) [216, 62] to study videogames [127, 115]. Cognitive Evaluation Theory (CET), a sub-theory within SDT, links motivation to three basic psychological needs; autonomy (a sense of volition), competence (a sense of mastery over tasks), and, in relevant contexts, social relatedness (feeling related to significant others) [115]. The extent to which experiences are able to satisfy these needs determines the level of (intrinsic) motivation a person would have for a given activity [217, 127].

The PENS model measures two additional constructs; presence/immersion and intuitive controls [127]. The PENS model is commonly applied in the evaluation of videogames but has also been used in other areas such as rehabilitation [231] or in a VR exercise platform [115]. The direct link to intrinsic motivation provided by this model makes it a promising candidate for this experiment. However, the model doesn't seem to offer a clear framework for actually evaluating each sub-aspect (autonomy, competence, relatedness, presence, and intuitive controls), which unfortunately makes it unsuited.

The Flow Questionnaire as described in [56] aims to measure the extent to which a participant is within a flow state. The prerequisites and benefits of being in a flow state are described in Section 7.1. Although thoroughly used and evaluated, this questionnaire has the same drawback as the IEQ, in the sense

[39] Nordin et al. [182] does state that this is partly due to the fact that this questionnaire is relatively new.

that it only measures one aspect of the gaming experience; flow. Although, flow, challenge, control, tension, and competence all relate to the balance between the challenges the game poses on the player and the skill required to overcome them, so these aspects are taken into consideration to some extent. However, the incapability to measure immersion and affect is enough to categorize this questionnaire as a poor fit for this experiment.

The GameFlow model [236] consists of 38 criteria derived from gaming user experience literature, which are structured into 8 distinct elements that conceptually map to Csikszentmihalyi's [57] concept of flow [237]. The 8 core elements of player enjoyment identified are concentration, challenge, skills, clear goals, control, feedback, immersion, and social interaction [236, 237]. The mapping to Csikszentmihalyi's concept of flow [57] only happened after these identified elements were observed to overlap closely with this concept.

The GameFlow model was originally designed as a general model for the evaluation of player enjoyment, applicable to all game genres and platforms [235]. Since its introduction into the field, a number of extensions and derivations of the GameFlow model that enable the model to target more specific experiences have been developed [237] (e.g. EGameFlow [82] - specifically for e-learning games, Pervasive GameFlow [121, 122] - to evaluate player enjoyment in pervasive games, RTS-Gameflow [64] - specifically for RTS games, and Social GameFlow [14] - to conceptualise how games might foster flow and cooperative learning through social play. See [237] for more examples).

The GameFlow model is a promising candidate to become the evaluation method for this study. It has similar advantages to the abovementioned Flow questionnaire [56], but improves on its shortcomings by focussing more specifically on videogames, as well as offering a wide range of variations to select whichever is best suited for this experiment. Yet, the large scope[40] makes this model less suited for online distribution and the overall design of this study. The goal is that participants can finish the experiment within a reasonable time (see 7.3 for experiment design) in order to prevent bias due to fatigue, boredom, or stress. Such an elaborate model would require too much time and (cognitive) resources from the participants, making this model a poor fit for this experiment.

The Presence Questionnaire [260] is one of the two[41] questionnaires developed by the U.S. Army to increase the use of distributed simulations that provide realistic training and rehearsal environments. It aims to evaluate and quantify the experience of being present in a virtual environment, as well as the influence of possible immersive factors [260]. The items in the questionnaire are meant to identify and measure to which an aspect of a virtual environment (singe factor

[40]In this context, large scope refers to the large number (38) of criteria in this model.

[41]The other questionnaire presented in this report is called the immersive tendencies questionnaire. This questionnaire is excluded from the list since it is intended to be administered prior to the introduction of subjects into the virtual environment [260]. It measures the characteristics of the participant, not of the simulation itself.

or sensory domain) engenders the sense of presence for a subject [260]. The questionnaire should also be helpful in identifying and measuring individual differences relating to immersion or as a correlate of task performance in virtual environments [260].

The Presence Questionnaire employs a 7-point scale format based on the semantic differential [69]. Each item is anchored at the ends by opposing descriptors, but, unlike the semantic differential, the Presence Questionnaire also provides an anchor at the midpoint.

Although presence / immersion is a key factor in game enjoyment [171, 130, 35] as well as a key factor for the overall effectiveness of (learning in) serious games [17, 20, 233, 105], it is only a single aspect of the gaming experience. As such, this questionnaire has the same shortcomings as seen before with the IEQ and Flow Questionnaire; it isn't capable of evaluating the whole gaming experience.

The Social Presence in Gaming Questionnaire [60] was developed to measure and evaluate the social processes and interpersonal dynamics associated with gaming. Although, for many people, gaming has connotations of social isolation, scientific literature does not provide convincing evidence for this [60]. On the contrary, research indicates that, just like regular games, videogames offer many opportunities for meaningful social interaction [60, 68, 71, 246]. In fact, socializing is the number one motivator for playing videogames according to gamers [71]. The importance of social interactions for shaping the gaming experience is testified by the overwhelming participation in virtual communities, massive online multiplayer games (e.g. World of warcraft), and the personal relevance of such communities to those involved [60].

Although I personally share the opinion that the social aspect is often underrepresented in conceptualisations and theoretical deliberations of game experience and game enjoyment [60], the singular focus of the SPGQ on social presence prevents it from evaluating the gaming experience as a whole, which is a requirement for the experiment.

The Simulator Sickness Questionnaire [131] is commonly used to evaluate and quantify the level of motion sickness experienced within games and simulations. It is currently the most commonly employed method for measuring motion sickness, partially due to the rise of Virtual Reality (VR) and Augmented Reality (AR) applications [15]. Although the physical well-being of players certainly is of importance in order for them to have a positive gaming experience, this is not very relevant for the type of game used in this experiment, since the aim is to evaluate the gaming experience, and not the level of motion sickness induced by the game.

The Game Experience Questionnaire [116] was intentionally designed to measure every single aspect of the gaming experience (as described in Section 7.1). Although the GEQ lacks formal peer-reviewed validation, it has become one of the most prevalent means to evaluate the different key aspects of the player experience [183]. This popularity arguably originates from the availability and ease of use of the GEQ [139], which I personally interpret to be beneficial characteristics.

Despite the lack of formal peer-reviewed validation, the GEQ (and its derivatives / variants) has been widely applied by game researchers and practitioners to a broad and diverse scope of game genres, user groups, gaming environments, and purposes [162, 183, 139]. Examples of applications of the GEQ include individual gamers playing a console game with a joystick [90], a co-located social game on a multi-touch tabletop for older adults [6], immersive virtual learning environments for (middle school) students [119], and massive online battle arena (MOBA) games for hardcore gamers [128]. Aside from being applied in a diverse range of studies, the GEQ has also been directly compared to other evaluation models listed in this paper (e.g. the Game Engagement Questionnaire [183], or the PENS [127]), and has been the topic of literature reviews (e.g. [139]).

The GEQ itself consists of 3 modules that are meant to be administered immediately after the game-session has finished; the core module, the social presence module, and the post-game module [116]. The GEQ also offers a more consise version of the core module. Each module consists of a series of short statements (e.g. "I felt frustrated", "I lost track of time") that are rated on a 5-point Likert scale, with the leftmost descriptor: "0 = Not at all" and the rightmost descriptor: "4 = Extremely" [116]. The GEQ provides a quantitative score for different categories (e.g. Competence, Sensory and Imaginative Immersion, Flow, Tension/Annoyance, Challenge, Negative affect, and Positive affect for the core module). The use of a Likert scale also allows participants to complete the questionnaire within a reasonable time.

Despite some criticism (e.g. [139, 191, 183])[42], the pervasiveness in literature still offers a strong foundation regarding the validity of this questionnaire. As such, the GEQ seems like a well-suited method to evaluate the gaming experience in this experiment. However, some adjustments are needed, which are discussed in Section 7.2.1.

### 7.2.1 Adjustments to the questionnaire

Although the GEQ is proven capable of measuring the gaming experience (see Section 7.2), there is another characteristic of games that is important to evaluate in this experiment; Replayability. The importance of replayability is discussed in Section 5.3, but briefly: Replayability refers to how much players enjoy playing a certain game for longer periods of time (whether that means for hours at a time or multiple shorter playing sessions). In this report, replayability does not refer to playing a game again after completing it or NG+ cycles, although this is also often considered to be a part of replayability. Replayability is especially important for the case study game, as, in order to aid with rehabilitation, the game should likely be played (and enjoyed) for longer periods of time. Replayability is also a good indicator that the game is enjoyed, not just as

[42] Most criticism lists the lack of formal / empirical peer-reviewed validation discussed in this section, but there are some more specific notes.

a novelty, but for its enjoyable gaming experience and intrinsically motivating capabilities [33].

In order to evaluate the replayability of the case study game, 6 statements will be added to the GEQ. These statements will be placed throughout the GEQ, potentially in a different order than listed here. The first 2 statements are phrased positively, and as such a higher rating will result in a higher score for replayability. The last 4 statements are phrased negatively, and higher ratings will lower the replayability score. The statements are intended to evaluate whether or not the game is able to continuously put players in new situations, whether or not the players feel inclined to play more of the game, and whether or not they consider the game to be boring.

1. I felt compelled to continue playing
2. I felt surprised
3. I wanted to stop playing
4. I found it predictable
5. I found it repetitive
6. I got tired of playing this game

Although I personally don't consider replayability as a prerequisite for a good game, in this context replayability will be considered a positive and desirable aspect of my game, and higher replayability scores are interpreted to be indicative of a more enjoyable gaming experience overall.

## 7.3 Method

The experiment is performed online, so there are no researchers physically present. Participants are sent a link to a web page that contains a short disclaimer about the experiment and a download button for the required files (see Appendix A). The downloadable files consist of the game itself, as well as a manual that guides participants through the experiment (see Appendix B). The only requirements for participation are being a minimum of 18 years old and having access to a computer. Somewhat of an interest in videogames is preferred but not required.

Participation was possible for a period of 2 weeks (from 3-11-2022 until 17-11-2022), so that participants could find a moment where they had no stress or time pressure, and could play the game in a similar context and state of mind as they would normally play videogames in.

The experiment employs a within-participant design, so every participant will play every condition. There are 3 different conditions, which means that there are 6 possible permutations regarding the order in which they will be played. Each participant is assigned a so-called 'participant number'. This number can have a value ranging from 1 to 6 and dictates the order in which the different conditions are played.

1. **Condition A** is the most "serious" condition. Participants have to traverse a series of spike pits by jumping over them. There are no enemies or other hazards present. It emulates the physical action of performing a certain exercise (in this case used as an input for the jump) repeatedly, without much regard for fun. This design philosophy does give the developers the most control over things like the frequency, timing, duration, and the total number of repetitions of the exercise.

2. **Condition B** is similar to condition A, but uses different environmental hazards to evoke the same player actions. The level still does not contain any enemies but it does contain more diverse hazards and geometry.

3. **Condition C** is the game as it is intended to be played according to the design strategy. It is a procedurally generated area[43] that contains different types of enemies, hazards, and challenges. This is the condition that aims for the best gaming experience, following the philosophy that a lack of motivation is the main issue plaguing physical rehabilitation therapy [204, 38]. It does sacrifice some control over the exercises (e.g. frequency, duration, etc.) in order to achieve this.

After being assigned a participant number, an online questionnaire is used to collect some demographic data about the participant (age, gender, and a subjective estimation of how experienced of a gamer they are). After this, participants can start the game and are instructed to play the tutorial. The tutorial is a short level that introduces all of the game's movement options, mechanics, hazards, and enemies. After completing the tutorial, participants play for 5 minutes in a randomly generated level to practice their newly learned skills. The goal of this is to flatten the learning curve a little bit, so that the initial challenge of playing a new game does not influence the gaming experience differently across the different conditions.

Participants are then asked to play a short level (either condition A, B, or C, depending on their participant number), which they evaluate afterwards using the modified version of the core module of the GEQ described in Section 7.2.1. This step is repeated 2 more times, so that every participant has played and evaluated every condition. Participants are then thanked for their time and the experiment is concluded.

[43]The use of random seeds ensures each participant does play the same generated area.

# 8 Results

This chapter is dedicated to the evaluation of both the data collected during the experiment, as well as the questionnaire itself. The conclusions that can be drawn from this data are discussed in Section 10.

## 8.1 Demographic data

During the 2 weeks that the experiment was live (from 3-11-2022 until 17-11-2022), a total of 55 people participated. All participants were aged between 18 and 28, with one exception of 60 years old. The participants consisted of 36 (65.5%) males, 17 (30.9%) females, and 2 (3.6%) people who identified as neither male nor female. When asked to rank how experienced of a gamer they consider themselves on a scale from 1-10, 17 people considered themselves below average ($\leq 5$), and 38 considered themselves above average ($> 5$). This discrepancy was to be expected since an interest in gaming was encouraged (but not required) in order to participate.

The 55 participants cover essentially the entire spectrum of gaming experience, ranging from people who never play videogames, or people who only play a single type of game, to people with 3000+ hours on a single game, people with global rankings, speedrunners, and aspiring game developers. This helped to approach the game from different angles and take multiple differing perspectives into account.

A more detailed summary of the demographic data of the participants can be found in Appendices C and D.

## 8.2 Questionnaire evaluation

Before reviewing the data collected, an evaluation of the questionnaire itself is needed to ensure that the answers to the questions accurately represent their respective concepts[44].

Since the GEQ uses a series of statements to evaluate a single concept (For example: there are 6 statements that all count towards immersion), it is important to ensure each individual statement correlates with others that fall into the same category. This so-called internal consistency can be determined by calculating the Cronbach's Alpha value for each GEQ component. Table 12 lists the Cronbach's Alpha values for each GEQ component, separated per trial.

[44]Please note that the Cronbach's Alpha values only indicate how much the questions represent the same concept. They do not evaluate which concept this is. It is merely presumed that these questions refer to concepts such as immersion or replayability.

| GEQ Component | $\alpha$ (Trial 1) | $\alpha$ (Trial 2) | $\alpha$ (Trial 3) | $\alpha$ (Average) |
|---|---|---|---|---|
| Challenge | 0.823 | 0.872 | 0.892 | 0.862 |
| Competence | 0.844 | 0.866 | 0.848 | 0.853 |
| Flow | 0.917 | 0.935 | 0.898 | 0.916 |
| Immersion | 0.871 | 0.873 | 0.883 | 0.876 |
| Positive Affect | 0.914 | 0.931 | 0.944 | 0.930 |
| Negative Affect | 0.659 | 0.718 | 0.752 | 0.709 |
| Replayability | 0.800 | 0.842 | 0.841 | 0.828 |
| Tension | 0.866 | 0.892 | 0.896 | 0.885 |

Table 12: The Cronbach's Alpha values for the internal consistency of each GEQ component used in the experiment.

With the exception of the 'Negative Affect' component, every single value has an average larger than 0.8, meaning that the questions used in these GEQ components are considered to have good internal consistency [79]. The only time that the $\alpha$ value drops below 0.7 is for the 'Negative Affect' component in trial 1. However, the $\alpha$ values for this component still average out larger than 0.7, which is still considered acceptable [79].

## 8.3 Data analysis

As explained in Section 7, the gaming experience was evaluated by presenting participants with a series of statements that they could rate their agreement with on a 5-point Likert scale, which ranged from 'not at all' to 'extremely'. The labels are then assigned numerical values (ranging 1-5) in order to quantify the data[45]. This means that the lowest possible value that a GEQ component can achieve is 1, whilst the highest is 5[46].

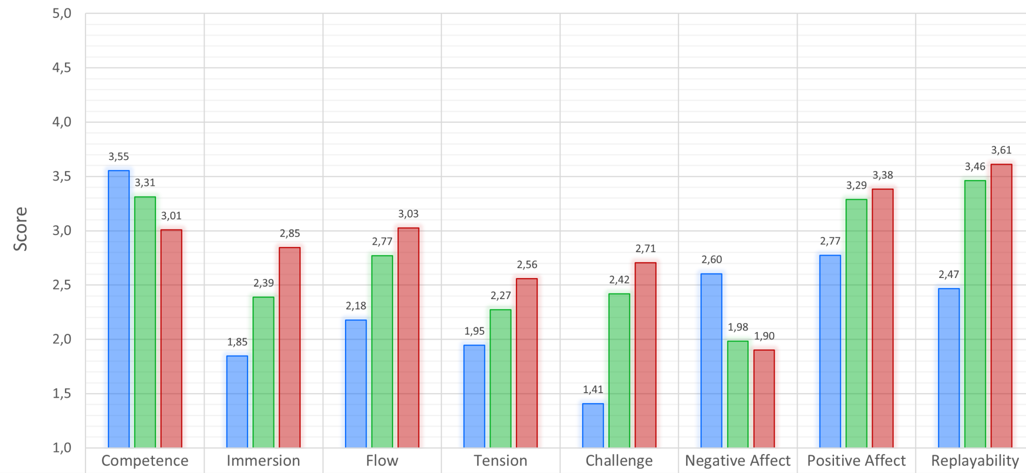
An initial look at the data indicates that condition C scores the highest for all GEQ components except 'Competence' and 'Negative Affect'[47]. Although players felt less competent in condition C compared to condition A, they felt more immersed, experienced higher levels of flow and tension, felt significantly more challenged, experienced more positive emotions, and considered the game to be more replayable. Condition B falls in between conditions A and C for every GEQ component. Figure 3 visualizes the average scores for each GEQ

[45] The labels are interpreted as follows: 'not at all' = 1, 'slightly' = 2, 'moderately' = 3, 'fairly' = 4, and 'extremely' = 5.

[46] All graphs in this report are adjusted for this and start at 1, not 0.

[47] Although Negative Affect is often considered a bad thing, negative experiences such as in-game frustration or tension are presumed to be essential for the overall gaming experience [92, 194]. Negative emotions may be essential for the in-game narrative or desired atmosphere. However, in my experiment, high 'Negative Affect' scores were sometimes associated with frustration, repeated failed attempts, feeling incompetent, and encountering bugs or glitches (based on the open comments of participants).

component across all participants. A more detailed overview of the results can be found in Appendices E and F.




| | Competence | Immersion | Flow | Tension | Challenge | Negative Affect | Positive Affect | Replayability |
|---|---|---|---|---|---|---|---|---|
| Condition A | 3,553 | 1,845 | 2,178 | 1,945 | 1,407 | 2,605 | 2,775 | 2,467 |
| Condition B | 3,313 | 2,388 | 2,771 | 2,273 | 2,418 | 1,982 | 3,287 | 3,461 |
| Condition C | 3,007 | 2,845 | 3,025 | 2,558 | 2,705 | 1,900 | 3,382 | 3,612 |

Figure 3: The GEQ scores for each condition, across all participants (N = 55). Note that this graph does not take the order in which the participants played each condition into account.

In order to determine if one value is actually significantly different than another, a series of one-tailed, paired T-tests was performed. The resulting P values can be found in Table 13. All A - C values are significantly different when using $\alpha = 0.05$. The only instances of 2 conditions not having a significant difference occur between condition A and condition B for Competence, and between condition B and condition C for Negative Affect, Positive Affect, and Replayability.

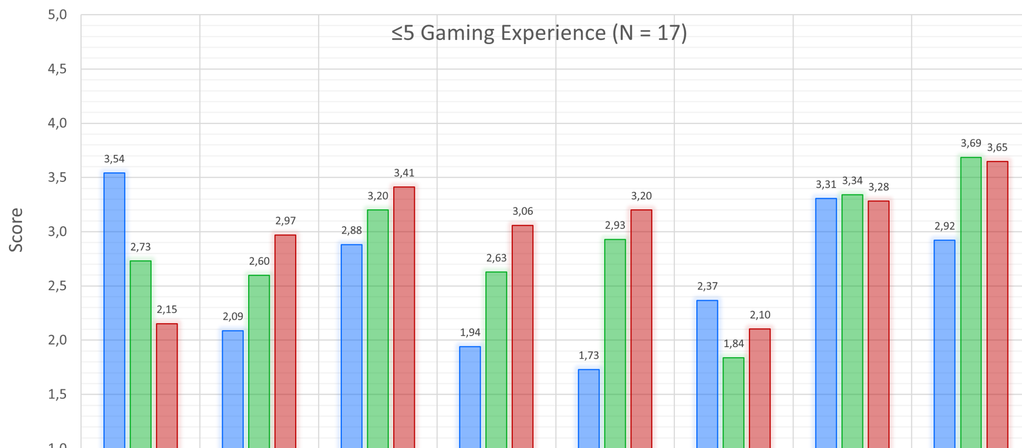
| P values | A - B | A - C | B - C |
|---|---|---|---|
| Competence | 0.064256 | 0.001985 | 0.013921 |
| Immersion | 1.665E-08 | 8.451E-12 | 3.499E-06 |
| Flow | 8.868E-06 | 2.055E-08 | 0.009996 |
| Tension | 0.037693 | 0.000194 | 0.049410 |
| Challenge | 4.145E-13 | 1.764E-16 | 0.005289 |
| Negative Affect | 6.892E-06 | 1.744E-06 | 0.184654 |
| Positive Affect | 0.000948 | 0.000210 | 0.210532 |
| Replayability | 1.002E-10 | 3.401E-11 | 0.065566 |

Table 13: The resulting P values from a series of one-tailed, paired T-tests. Using $\alpha = 0.05$, H0 = 'Both values are the same', and H1 = 'One value is significantly higher than the other', we say that if 2 numbers have a P value lower than 0.05, they differ significantly.

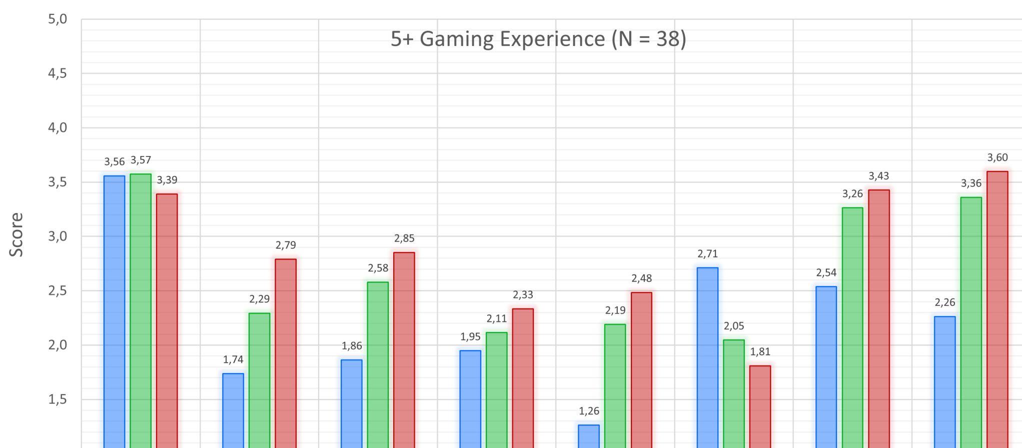
As mentioned in Section 7.3, the participants were asked to rate themselves on a 1-10 scale based on how experienced of a gamer they consider themselves to be. Although this score is subjective, by, somewhat crudely, separating at the halfway point, the participants can be divided into 2 groups; those who consider themselves above average gamers (N = 38), and those who consider themselves below average (N = 17). Figure 4 visualizes the average GEQ scores of both groups.

Both groups seem to agree that condition C is the most challenging and condition A is the easiest, with condition B falling somewhere in the middle. However, the less experienced group experiences this difference to a greater extent. Although both groups felt almost equally competent whilst playing condition A, the more experienced group manages to maintain a similar feeling of competence across all conditions, whereas this feeling quickly dwindled for the less experienced participants. The less experienced participants also seem to experience higher levels of immersion, flow, tension, and challenge, regardless of the condition.

Overall, the more experienced players seemed to prefer condition C, while the less experienced players have a slight preference towards condition B, which, although considered to be less challenging than condition C, made them feel more competent, evoked less negative and more positive emotions than any other condition, and was experienced as being the most replayable. These results were to be expected, since research shows that scaling difficulty and challenge seemed to increase enjoyment for experienced players whereas more casual players seemed to favour lower difficulties regardless of their performance [9].




| | Competence | Immersion | Flow | Tension | Challenge | Negative Affect | Positive Affect | Replayability |
|---|---|---|---|---|---|---|---|---|
| Condition A | 3,541 | 2,088 | 2,882 | 1,941 | 1,729 | 2,368 | 3,306 | 2,922 |
| Condition B | 2,729 | 2,598 | 3,200 | 2,627 | 2,929 | 1,838 | 3,341 | 3,686 |
| Condition C | 2,153 | 2,971 | 3,412 | 3,059 | 3,200 | 2,103 | 3,282 | 3,647 |




| | Competence | Immersion | Flow | Tension | Challenge | Negative Affect | Positive Affect | Replayability |
|---|---|---|---|---|---|---|---|---|
| Condition A | 3,558 | 1,737 | 1,863 | 1,947 | 1,263 | 2,711 | 2,537 | 2,263 |
| Condition B | 3,574 | 2,294 | 2,579 | 2,114 | 2,189 | 2,046 | 3,263 | 3,360 |
| Condition C | 3,389 | 2,789 | 2,853 | 2,333 | 2,484 | 1,809 | 3,426 | 3,596 |

Figure 4: The GEQ scores for each condition, across all participants, separated by the subjective gaming experience score participants gave themselves. Note that this graph does not take the order in which the participants played each condition into account.

Condition A yielded the worst gaming experience overall. Although it made players feel very competent, a lot of participants commented on the high levels of repetition and the overall lack of challenge. Some of the participants' comments include: "After the buildup of the previous two levels, this level feels completely out of place and boring, as there were no enemies and little challenge", "repetitive platforming challenge", "boring", "It were only normal long jumps, and it felt really repetitive, at some point I wondered what the goal was for it", and "It felt very repetitive with nothing actually happening. No enemies. It was chill but kind of boring". However, not all comments were negative, some participants, especially the lesser experienced ones, were relieved with the lower challenge, commenting things such as: "I liked this level, but that's probably because I'm bad", "I think the levels (apart from the A condition) were too hard (at least for me, but maybe I'm just too inexperienced as a gamer)", and "this was better".

Condition B received little attention in the open comment section. A few participants commented that they died during their first attempt. Some other participants commented on the hitboxes of the thorns, which were generally experienced as being too large for their respective sprites. In general, the comments seem to align with the graph in the sense that condition B doesn't particularly stand out in any category.

Condition C received a lot of comments. As one might expect, condition C received the most comments about participants who died during their attempts. There were also a number of similar comments regarding the hitboxes of the thorns, as mentioned above. Comments that were more specific to this condition include: "This trial, in contrast to the other 2, actually felt quite good to play. It was somewhat successful at replicating Hollow Knight's sprawling caves and it had quite a variety of things to do. The main thing that I noticed was that because this level was way more open, it felt better to play. Jumping in small amounts feels kinda bad, and having to fight for example the shieldbearer enemies with a low ceiling is designed kinda unfairly. In its current state, the game benefits from big rooms.", "A well put together level with a good pace. I like the sadistic placement of heals. [...] the shield guys desperately need a counter to just jumping on their head.", and "Because I didn't know where I was going and there were so many routes/possibilities, I became extra curious to what was yet to come. + I felt less competent during the game (because it was harder). However, as I was getting closer to the end, and especially when I made it to the end, I actually felt much more capable. This gave me motivation / incentive to continue playing and being even more challenged"[48].

[48] This comment is a translation, the original comment was made in Dutch and can be found in Appendix G

# 9 Discussion

This chapter discusses all the factors that might have had a negative impact on the validity of the experiment results. For the sake of transparency and thoroughness, even small factors are listed here, resulting in a rather elaborate list.

## 9.1 Context

Firstly, the context within which participants performed the experiment may have had an influence on their overall experience. Contextual factors such as distractions or time pressure, as well as personal factors such as feeling sick or stressed, can influence a player's gaming experience [170]. Especially time pressure can be a problem, since it doesn't affect all trials equally, but has more effect on the later trials.

Although the participants were specifically instructed to perform the experiment in a context that they would normally play videogames in, absent of time pressure, and at a time that they were feeling good, not all participants may have obeyed these instructions. Some lesser experienced participants may not have had a clear idea of what "a context that they would normally play videogames in" meant for them, as they don't regularly play videogames. Since the physical space within which play exists is of influence of the experience [160], the different physical spaces chosen by the participants may also have influenced their experiences.

The hardware used to perform the experiment is also considered an contextual factor for the experiment. Due to characteristics like being 2D, using pixel art, and using procedural level generation, the game is already pretty lightweight, meaning that most devices should be able to run the game at 60fps[49]. However, it is possible that not all devices could maintain this framerate. One participant did explicitly mention that they experienced occasional drops in frame rate. Technical issues such as these can potentially influence the overall gaming experience [170]. However, the 3 conditions were relatively small levels compared to the tutorial and especially compared to the '5-minute free play' level, so these issues are less likely to have appeared during the actual trials.

[49]The game is capped at 60fps.

## 9.2 Participants

Some notes can also be made regarding the participant demographic. The demographic data of the participants is summarized in Section 8.

The vast majority of the participants (98%, N = 54) were aged between 18 and 28. These participants are so-called "digital natives": they were born in a computerized world and are generally used to handling all kinds of software products and games [93, 197, 256, 10, 19]. This pre-existing familiarity with technology is reflected in their self-perceived experience with games: the majority of the participants (69%, N = 38) consider themselves to be an above-average experienced gamer[50]. This means that most participants will already be somewhat adept at playing videogames, and since factors like challenge, competence, tension, and flow play key roles in shaping the gaming experience, this existing familiarity with technology, especially with videogames, and the relatively high levels of skill developed as a result, will have helped to shape their gaming experience during this experiment.

However, this might not have had a negative impact on the validity of the results as it is counteracted by a few other factors. Firstly, despite having a serious purpose, the case study game is still aimed at people who already have an interest in videogames. I'm of the opinion that the gamification of serious tasks, such as learning or exercise, is only really effective in promoting these tasks if the target audience is interested in games in the first place. Also, since the experiment employs a between-participant design with the condition order shuffled, the level of experience of participants will, on average, have affected every condition equally.

Because the experiment was performed with a relatively young demographic, the results may not accurately represent the game's target audience in practice, which are people following physical therapy programs. Although not exclusively, the expectation is that the majority of this target demographic consist of elderly people, as they are more likely to experience incidents, primarily falls [248, 46, 61], that require physical rehabilitation, due to risk factors such as age-related decreases in postural control and strength [173, 214]. Compared to younger users, elderly users also tend to be more interested in games with a perceived meaningful purpose such as improving motor skills [5]. Since elderly people can respond differently to videogames compared to younger people [61], and, in contrast to the relatively experienced participants in this experiment, elderly people frequently lack gaming experience [180], the participants' gaming experience may not accurately represent the gaming experience that the actual target demographic will have.

Regarding the behaviour of the participants: not all participants may not have followed all instructions correctly. However, great effort was made to ensure that the instructions were understandable and unmissable. For example: the

[50] This phenomenon can also be the result of people being more likely to participate in this experiment if they already possess an interest in videogames.

only way to access the game was to download it from a web page, which already contained the most important instructions (see Appendix A). Participants were required to confirm that they had read and understood these instructions in order to enable the download button. In addition, the only way to access the online questionnaire was via a link inside the experiment manual (see Appendix B), so any participant who submitted their results must have had this manual open. Regardless, there is a possibility that not all participants performed the experiment the way it was intended. The main problems that I encountered were: (1) participants who performed the experiment over multiple sessions, rather than in a single one, and, (2) participants who refused to read the on-screen tips during the tutorial.

Lastly, due to the method of participant recruitment, some of the participants are personally acquainted with the researcher, and may have been hesitant to give harsh feedback as a result. This effect should be mostly negated by the anonymization of the data, as well as the absence of the researcher while the experiment was performed.

## 9.3 Game

Some factors arise from the game itself. Firstly, there is the overall lack of polish mentioned in Section 6.9, which can influence a game's playability, immersion, engagement, and alter a player's impression of the game as a whole [226, 170, 49]. Players are more likely to forgive minor bugs / hiccups in a game if their initial impression of said game is that it is of high quality [245].

In a similar vein, there is a possibility that some players have encountered bugs or glitches within the game. To the best of my knowledge, there are no participants that have encountered any game-breaking bugs or glitches. However, some participants noted minor bugs such as shurikens remaining stuck on colliders that no longer exist or the possibility to get stuck in the ceiling in the tutorial[51]. One participant actively tried to find bugs or glitches after they had completed the experiment and found that the level generation algorithm created a dead end if they input an incorrect desired level length[52]. Aside from the large hitbox on the thorns potentially being perceived as an unintended bug, and the shielded enemies sometimes showing blood particles even when they're hit on their shield, no participants remarked on bugs in any of the 3 conditions.

Multiple participants noted similarities between the case study game and other existing games; most notably Hollow Knight, although Dead Cells was also mentioned. As mentioned in Section 6.5, these games did serve as major sources of inspiration for the case study game. However, due to the rather limited experience the game offers during the experiment, the game may not have been able to sufficiently distinguish itself. This can lead to comparisons between the

[51] Both of these occurred in the tutorial level and not in an actual condition.
[52] This situation will not be encountered in the experiment when using the parameters as instructed.

case study game and its inspirations, which might affect a participant's opinion of the game.

Then, people may have taken different routes through the level, thus having different experiences. This is only possible in condition C, as conditions A and B are completely linear. However, although it does contain small loops and side tracks, condition C still doesn't allow for many significantly different routes through the level.

Section 6.9 already touched upon this issue, but since the game was only used as a means to evaluate the design strategy, certain aspects of the game, such as the permanent upgrades across playthroughs, aren't implemented or tested. As such, the long-term effects regarding intrinsic motivation are unknown. The levels of enjoyment, and, by extension, intrinsic motivation players experienced during the experiment may be attributable to novelty or curiosity, and potentially won't persist for longer periods of time.

In a similar manner to how the game was never tested using its actual target demographic (see Section 9.2), the game was also never tested when using exercises as inputs. It is assumed that, even though it might influence the gaming experience, it will do so equally across conditions, meaning that the conclusions drawn from the data are still valid. However, this assumption may not hold true, and further experimentation is necessary.

Lastly, the main method with which the proposed design strategy aims to enhance the gaming experience of serious games is to make the development process closely resemble that of regular, non-serious games, with the assumption that the final product will offer comparable levels of fun / entertainment value. Therefore, it follows that if a developer is incapable of making fun, non-serious games, the same will hold true for serious games. Although I am personally pretty confident in my abilities as a developer, it is by no means a certainty. However, regardless of the overall level of fun of the game, it should have affected all 3 conditions equally.

## 9.4 Literature & evaluation techniques

This first note isn't specifically about the experiment data but is more general across the report. Not all literature that was used to form the scientific foundation of the design strategy and has influenced my decision-making throughout the design and development of the case study game may have been equally applicable. For example, I used a lot of sources on 3D level design despite making a 2D game. And although there is a lot of transferable skill between 2D and 3D game design [NS10], some elements can differ and this may have led to incorrect conclusions being drawn. Similarly, sources on educational serious games may not accurately represent motor-based serious games.

During the experiment, the gaming experience was measured using a questionnaire. The advantages of the usage of questionnaires are touched upon in Section 7.1. Naturally, there are also drawbacks. While questionnaires enable researchers to measure subjective metrics such as the gaming experience (albeit within the parameters set by the items of the questionnaire [182]) [171], this reliance on participants' subjective opinions and self-reports can be problematic [230, 125]. Aside from the more obvious problems, such as participants not taking a questionnaire seriously, there is also a less evident and more profound problem – namely the wording of the questions themselves that reduce the face validity [3], and equally the way in which (and the scale upon which [102]) the participants answer them [182].

Regarding the usage of the Game Experience Questionnaire specifically, the most notable criticism is the lack of formal peer-reviewed validation, as mentioned in Section 7.2. In addition, Norman [183] notes that although the GEQ seems reasonable and applicable for studying player experiences with videogames, it is likely that it should be tailored for different genres. Norman elaborates upon this statement with examples that are likely to require such tailoring, such as games that do not involve a narrative or narratives that are intended to put the player in a bad mood (e.g. survival horror games), and non-competitive games (e.g. sandbox games) [183].

Although the GEQ was adjusted to include a score specifically for replayability (see Section 7.2.1), no questions were removed from the original GEQ core module, meaning that questions about the narrative were left in, even though the game didn't contain any explicit narrative[53]. This was an intentional choice, as I was also interested in seeing how the different conditions affected participants' perceptions of the narrative, even though there wasn't any. One participant did remark that they thought the inclusion of such questions was unnecessary and only bloated the questionnaire.

Conventional evaluation methods such as the questionnaire used in this experiment may not be fully applicable to certain forms of interaction, such as using physical rehabilitation exercises as inputs. Bernhaupt et al. [25] states that "new forms of interaction techniques, like gestures, eye-tracking, or even bio-physiological input and feedback present the limits of current evaluation methods for user experience, and even standard usability evaluation used during game development". As such, the data collected during the experiment may not accurately represent how the game will be experienced when using the intended GACE mappings.

[53]Some (e.g. [NS20]) argue that every level has a narrative to it, developers can consciously design it, or let it arise naturally, but a perceived narrative will be present regardless.

# 10 Conclusion

Although the game did not make use of any physical exercises as inputs during the experiment, it is programmed in a way that such exercises could realistically be used as inputs, in a practical sense (theoretically possible to achieve using existing hardware, different kinds of signals can all be interpreted, see Section 3.2.3), from a game design standpoint (the game is created in such a way that it can be balanced to achieve the desired level of difficulty, or to specifically incentivize certain in-game actions and by extension, certain physical exercises[54]), and in a medical sense (lack of motivation to perform repetitive exercises is generally considered to be one of the primary challenges of physical rehabilitation programs, see Sections 2.2 and 4.1). The development of, and testing with, the required hardware could be a potentially interesting area for the continuation of this project (see Section 11). With the implementation of these features, the game could realistically be considered a serious game, since it is capable of serving a (serious) purpose aside from pure entertainment.

If the game is controlled using physical exercises, all 3 conditions that were used during the experiment could theoretically be used. However, Condition C was perceived to have the best gaming experience overall. This is especially true for more experienced gamers, which is in line with the target audience for this game[55]. The differences in gaming experience between Condition C and other conditions are mainly attributed to the more complex and diverse level design and the resulting higher levels of challenge. As such, I would conclude that Condition C is the most suitable for the game, should it become an actual product that is used to aid with physical rehabilitation, assuming that the implementation of physical exercises as input method will affect the gaming experience of all 3 conditions equally. Condition C is also the one that is the most direct result of the proposed design strategy, since it makes the least concessions for the serious aspect of the game (although it can still be implemented).

Because by implementing the serious aspects of the game near the end of the development process, certain level design challenges arise for the developers; the primary one being the balancing of the control that the therapists have over the exercises in terms of type of exercise, amount of repetitions, frequency, etc. and the overall fun of the game. Aside from the design strategy attempting to prevent or mitigate these 'threats to fun', this experiment has also shown the effectiveness of certain tricks that developers can employ to reduce this effect. Using procedural level generation, or even reskinning areas, so that even though the gameplay is the same, the level is still perceived as being more diverse, challenging, and less surprising, all help alleviate these 'threats to fun'. This phenomenon is reflected in the data (see Section 8.3). And my expectation

[54] Though, this is still a somewhat unexplored area and a potentially interesting topic for the continuation of this study (see Section 11)

[55] Serious games work best for people who have a preexisting interest in videogames as a whole (see Section 9.2).

is that there are many more of such tricks that game developers could apply in creative ways to further reduce these ‘threats to fun’. My hope is that, should this design strategy gain traction and become more widespread / popular, the number of such tricks and the knowledge on when and how to apply them will increase as well.

In conclusion, I believe that this study has shown that it is possible to make serious games that offer a better overall gaming experience and are more intrinsically motivating than the vast majority of the currently available ones, without forcing major concessions upon the serious aspect of the game. Further research is needed to fully determine the exact effect that this design strategy has on the gaming experience as a whole, as well as to expand the list of creative tricks that developers can employ to counter the ‘threats to fun’ that arise with the implementation of the serious aspect towards the end of the development process. Section 11 mentions a few interesting potential options for the continuation of this project, both in a scientific sense, as well as by looking at how to improve the case study game as a product.

## 10.1 Personal experience

As mentioned in Section 4, in addition to the posed research questions, I will provide a subjective evaluation of my personal experience working with this design strategy.

Although the strategy mandated me to introduce certain limitations[56] at the beginning of the development process, I actually perceived these as being beneficial, rather than limiting. For me, the start of a new project can often be very challenging and, at times, intimidating. Typically, when I start a new project, it is based on an idea that I had beforehand. This can be a spontaneous idea or can originate from something that inspired me, such as an unfinished concept for a previous project. Regardless, starting from an idea can help to narrow down the scope of a project and prevents me from being overwhelmed by creative choices.

Although I’m of the opinion that the best projects are those that arise from a preexisting idea, that is often not how serious games work. Typically, serious games are commissioned to (help) achieve a predetermined goal, and the concept of the game is then thought of. As such, the developers are forced to create a new concept for a serious game from scratch. Imposing certain, small limitations in a similar way as I experienced with the case study game can help narrow down the options and provide a smaller, more manageable array of choices that still allows for tons of creative freedom. Not all developers may experience this in the same manner as I did, but for me, these limitations actually proved to be helpful.

[56]This is referring to requiring the game to work with multiple, distinct input signals (see Section 3.2.3). Although requirements such as the focus on replayability (see Section 5.3) can also be considered.

The fact that I even imposed additional limitations upon myself by deciding to make a 2D game from the very start is a testament to this. Besides the workload argument (see Section 6), narrowing down the options like this in order to prevent myself from being overwhelmed by all the possibilities was also an important motivator for this decision.

An aspect of the design strategy that I did struggle with was the intentional ignoring of the serious aspect. It is very difficult not to imagine scenarios of how the finished product will be used whilst you're working on it. This may have, albeit subconsciously, influenced my decisions and affected the final product, although I do feel like this effect is somewhat minimal. I personally don't think that this has had a significant influence on the game design decisions I made, but, as stated before, this effect might have happened subconsciously.

Lastly, there are certain aspects of the game that I went a bit overboard with. The best example is probably the level generation algorithm as mentioned in Section 6.7.4. Most of the HCAs that are used to generate levels never even made an appearance in the experiment. Although this may seem like unnecessary extra work when looking at the game as just a means to perform an experiment, if the game is viewed as an actual product, a large number of HCAs is required to ensure sufficient variation and replay value in the generated levels. However, I personally feel that this phenomenon, which is discussed in more detail in Section 6.9, is largely due to the distinction between the game as a means to perform the experiment and the game as a product, and not caused by the design strategy.

Overall, the strategy resembles conventional design strategies for regular games rather closely. The key ways in which the 'Sneakily Purposeful Games' design strategy distinguishes itself are occasionally noticeable, but haven't really affected me on a daily basis. Most aspects of the development are the same as they would be when using conventional design methods. Most of the time is still spent programming or creating assets. This is of course an intended aspect of the design strategy (see Section 3.3.1), but, in my experience, it worked as intended, and the work I was doing on a daily basis felt familiar and not out of place. I did not feel like I was working with an unfamiliar tool or using a new approach. However, other game developers might experience this differently, since, although this was my first time using the design strategy, I might still have been more familiar with it from the start due to the fact that I designed it in the first place.

Nonetheless, this was my experience with this design strategy. I enjoyed working using this strategy; it limited me in just the right ways and guided me to create the desired product. Although I personally don't expect that this design strategy will be suited for all types of serious games (see Section 3.3.2), I'm convinced of its potential. My hope is that other game developers will adopt and improve upon this strategy, such that it could eventually prove to be a valuable and efficient tool to create better and more enjoyable serious games.

# 11 Future work

This chapter lists possible areas / topics that I would personally consider interesting to focus on for the continuation of this project. The chapter is divided into 2 sections. Section 11.1 lists some ways in which the project can be continued or expanded upon with the primary goal to provide scientific value, whilst Section 11.2 discusses some improvements or additions that could be made to the game to make it a better product.

## 11.1 Scientific continuation

The next logical step in the continuation of this project would be to perform a similar experiment, but use physical exercises as inputs. Doing so would give more insight into both the game as a product and the design strategy as a whole. Additionally, such an experiment would yield more clarity regarding previously made assumptions, such as the assumption that the differences in gaming experience across the 3 conditions would be similar whilst using physical exercises as inputs (see Section 9).

Similarly, a study regarding the long-term effects on the fun, enjoyment, and intrinsic motivation of the game could indicate whether the game is actually able to maintain the currently reported levels over longer periods of time, as well as help filter out positive feedback on the game as a result of novelty. Such a study could also aid in finding ways to extend the period of time during which the game is able to intrinsically motivate its players. If the game remains fun and engaging for longer periods of time, it could be used for rehabilitation programs of different durations.

Lastly, developing another game using the same design strategy, ideally, one that is wildly divergent from the game described in this report, could give a lot of insight regarding the design strategy. Aside from collecting more subjective feedback from the developers on their process, it could help indicate if the design strategy is also suited for, among many other thing, different videogame genres.

## 11.2 Improving the game as a product

There are also things that can be done to continue the development of the case study game. Firstly, the items discussed in Section 6.9 should be addressed. Adding more content in the form of areas, levels, enemy and hazard variety, pick-ups and upgrades, boss fights, secret areas, or easter eggs would greatly help improve the replayability of the game. If there is more content to discover, players will take longer to discover it all, and the thrill of discovering something new can remain present in the game for longer.

In addition to this, adding the features necessary for this game to become a product is, in my opinion, also vital for its success. This means adding sound, extra polishing the game, implementing accessibility options, and the adjustable pacing functionality mentioned in Section 5.4. This list is also likely to expand even further as new features are implemented and tested.

On a more specific note, focussing on the development of equipment to measure physical exercises and translate them into digital signals the game can interpret could also be an interesting project. In this report, it is simply stated that this is possible, but it isn't actually implemented. Aside from being a prerequisite for the game to actually function as intended, the development of such equipment will bring forth new and unique challenges, the solutions to which can offer scientific value and also potentially fundamentally affect the way that the game is played.

Somewhat more ambitiously, it could potentially be helpful to develop an AI that can autonomously play this game. This could be helpful for players that are unable to perform all the required inputs simultaneously, a problem mentioned in Section 3.3.2. If the player character could also be controlled by an AI, these players would only need to perform the actions that they are able to do. For example: a player controls the jump button, but the steering is done by an AI, such that the player only needs to concern themselves with the jump.

Naturally, such a system would have an immense impact on the entire gaming experience, from the perception of fairness and challenge, to the physical input device required. This would also open up new possibilities for research.

# Acknowledgements

Before I end this report, I would like to express my gratitude to some of the people who helped make this project possible by supporting, motivating, guiding, and advising me throughout the process.

First, I would like to thank my mother, Sandra Goutier, who helped me a lot with the organizational aspects of the project and without whom I would not even be in the position to start this project, as well as my dad, Ad Eijkemans, who served as a sincere and affable conversation partner and was always happy to provide feedback and challenge me to think further.

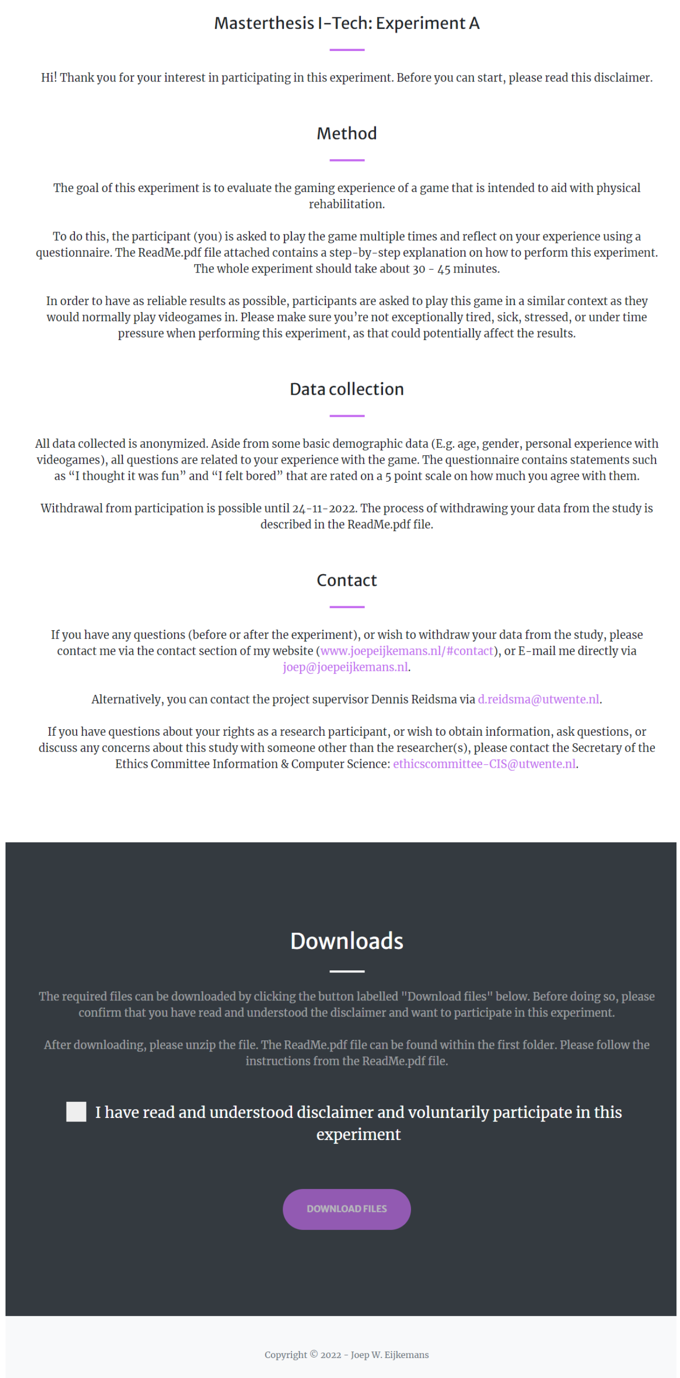
I would also like to thank my supervisor dr.ir. D. Reidsma for his guidance, patience, valuable feedback, and his overall insight in this field.

In addition to this, I would also like to thank the other graduation committee members, dr.ir. R.W. van Delden and dr.ir. A.A.M. Spil for their feedback.

Lastly, I am sincerely grateful to all the people that participated in the experiment and helped playtest the game. The enormous amount of feedback I collected from them was not only indispensable for this project, it is also a testament to their faith in this project and in me as a game developer, and served as a great motivator.

# Appendix

## Appendix A: Participation webpage



### Masterthesis I-Tech: Experiment A

Hi! Thank you for your interest in participating in this experiment. Before you can start, please read this disclaimer.

### Method

The goal of this experiment is to evaluate the gaming experience of a game that is intended to aid with physical rehabilitation.

To do this, the participant (you) is asked to play the game multiple times and reflect on your experience using a questionnaire. The ReadMe.pdf file attached contains a step-by-step explanation on how to perform this experiment. The whole experiment should take about 30 - 45 minutes.

In order to have as reliable results as possible, participants are asked to play this game in a similar context as they would normally play videogames in. Please make sure you're not exceptionally tired, sick, stressed, or under time pressure when performing this experiment, as that could potentially affect the results.

### Data collection

All data collected is anonymized. Aside from some basic demographic data (E.g. age, gender, personal experience with videogames), all questions are related to your experience with the game. The questionnaire contains statements such as "I thought it was fun" and "I felt bored" that are rated on a 5 point scale on how much you agree with them.

Withdrawal from participation is possible until 24-11-2022. The process of withdrawing your data from the study is described in the ReadMe.pdf file.

### Contact

If you have any questions (before or after the experiment), or wish to withdraw your data from the study, please contact me via the contact section of my website (www.joepeijkemans.nl/#contact), or E-mail me directly via joep@joepeijkemans.nl.

Alternatively, you can contact the project supervisor Dennis Reidsma via d.reidsma@utwente.nl.

If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee Information & Computer Science: ethicscommittee-CIS@utwente.nl.

### Downloads

The required files can be downloaded by clicking the button labelled "Download files" below. Before doing so, please confirm that you have read and understood the disclaimer and want to participate in this experiment.

After downloading, please unzip the file. The ReadMe.pdf file can be found within the first folder. Please follow the instructions from the ReadMe.pdf file.

☐ I have read and understood disclaimer and voluntarily participate in this experiment

DOWNLOAD FILES

Copyright © 2022 - Joep W. Eijkemans

Figure 5: A full page screenshot of the webpage from which participants could access the required files. The 'Download Files' button will only become interactable if the participants confirm to have read and understood the disclaimer and their participation in this experiment is voluntary.

## Appendix B: Participation manual

The participation manual can be found on the next page.

# Participation manual - intro:

Hello. Thank you for your participation in this experiment. The goal of the study is to evaluate the gaming experience of a 2D platformer game when the levels are designed using 3 different methods.

This manual will guide you through the experiment step-by-step. The entire experiment should take around 30 – 45 minutes, depending on your playstyle. Even so, please take a moment when you're not in a hurry, as the stress could potentially influence your results.

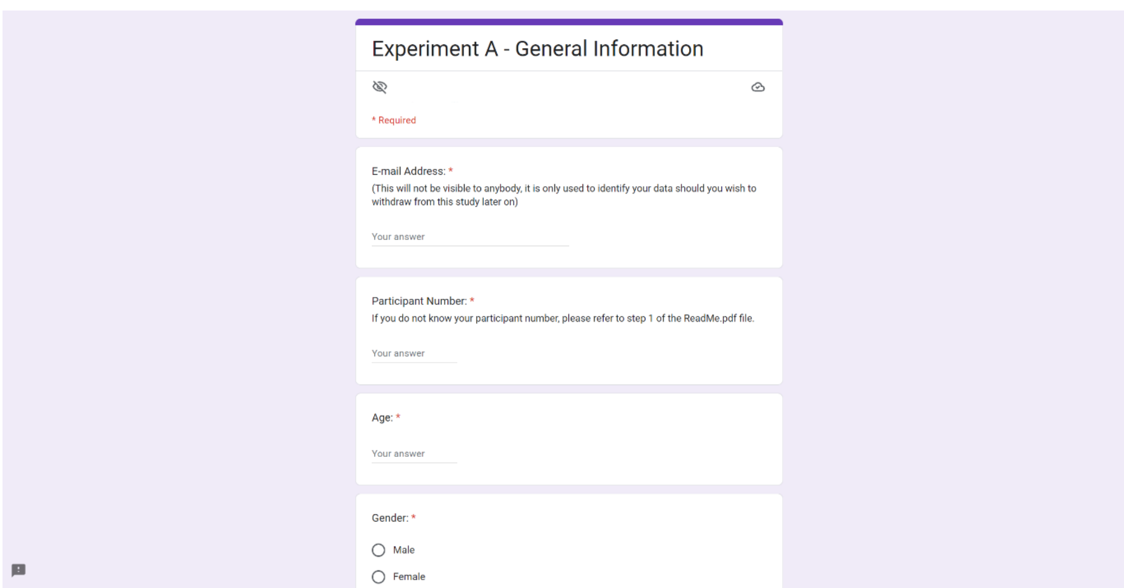
# Step 1: Participant number

Different participants will do the conditions in a different order. For this, participants are assigned a 'Participant number'. Get your participant number here:

https://www.joepeijkemans.nl/Portfolio/Projects/SneakilyPurposefulGame/Participate/GetParticipantNumber/

# Step 2: Participant data

Please fill out the first section of this questionnaire: https://forms.gle/duxc6qbGrYWss6ju9



Experiment A - General Information

* Required

E-mail Address: *
(This will not be visible to anybody, it is only used to identify your data should you wish to withdraw from this study later on)

Your answer

Participant Number: *
If you do not know your participant number, please refer to step 1 of the ReadMe.pdf file.

Your answer

Age: *

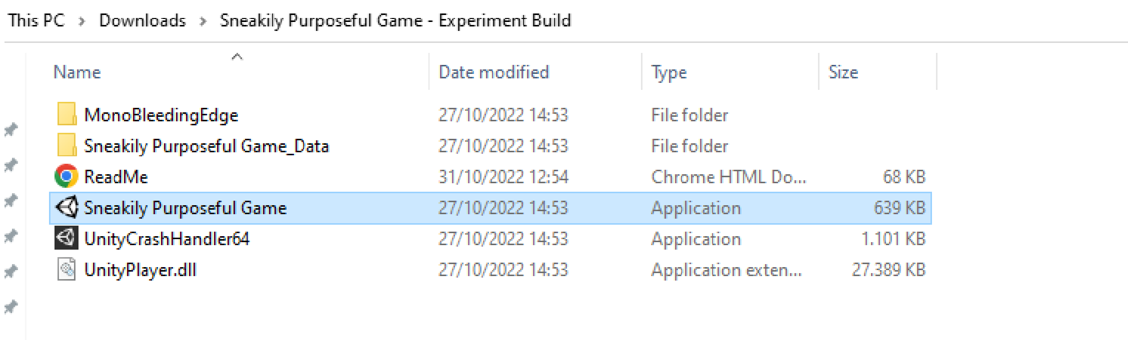
Your answer

Gender: *

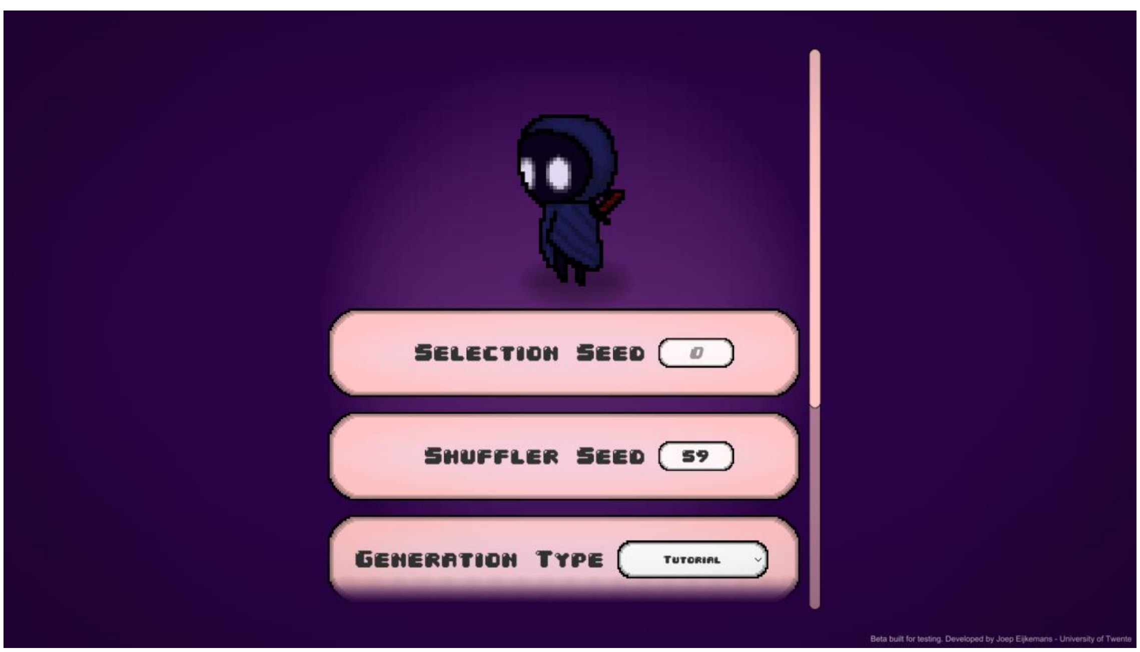
- Male
- Female

# Step 3: Starting the game

The game can be found in the same folder as this manual, it is an executable file named 'Sneakily Purposeful Game' (See image below). Double click this application to run it.




This should send you to the main menu screen, which is the screen that you see below. If you're working on a single screen, you can use ALT + TAB to switch between the game and this manual.



# Step 4: Starting the tutorial

The main menu screen has some input fields that are used to tell the game which condition you wish to play. The first thing is the tutorial; A short level that introduces all of the game mechanics and enemies.

For this, please enter the following values in the input fields (use the scrollbar to scroll down):

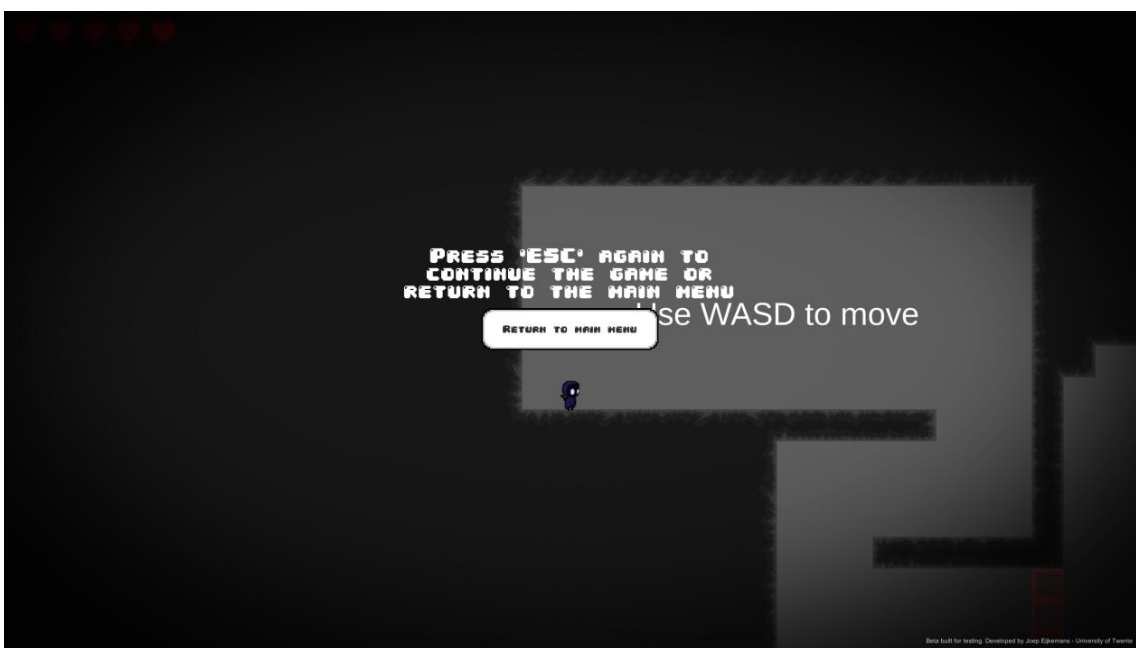
| | |
|---|---|
| Selection Seed: | 1 |
| Shuffler Seed: | 59 |
| Generation Type: | Tutorial |
| Level Type: | Cave Area |
| Level Length: | (Leave at 50) |


Scroll down and press the ‘Start’ button.

# Step 5: Playing the tutorial

After a short loading screen, you should arrive in the tutorial level. Follow the on-screen tips to complete the tutorial (please read every tip). No worries, it is impossible to die here.


Whilst in the tutorial, you can use the ESC key to go back to the main menu



Hit the gong to complete the tutorial and return to the main menu

# Step 6: Playing around

After completing the tutorial, its time to quickly practice the skills you've learned. Go back to the main menu and enter the following values (make sure to set the Generation Type to 'Generated Area'):

| | |
|---|---|
| Selection Seed: | 1532 |
| Shuffler Seed: | 59 |
| Generation Type: | **Generated Area** |
| Level Type: | Cave Area |
| Level Length: | (Leave at 50) |


This will generate a level where you can just play around in for a bit. Please set a 5 minute timer for yourself and play this level for 5 minutes. You can use any timer you prefer, but for convenience: [https://www.online-stopwatch.com/countdown-timer/](https://www.online-stopwatch.com/countdown-timer/)

After the 5 minutes are done, press ESC and return to the main menu.

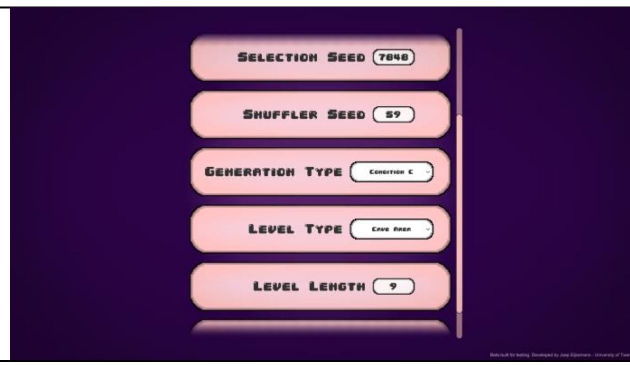
# Step 7: Trial 1

Now it's time to move on to the actual experiment. You will play 3 different short levels of the game. After this there is a short questionnaire. Please enter the following values in the main menu.

To see which condition you should choose for trial 1, please refer to this table:

| **Trial 1** | |
|---|---|
| **Participant number** | **Condition** |
| 1 | C |
| 2 | B |
| 3 | A |
| 4 | A |
| 5 | C |
| 6 | B |

| | |
|---|---|
| Selection Seed: | 7848 |
| Shuffler Seed: | 59 |
| Generation Type: | [YOUR CONDITION] |
| Level Type: | Cave Area |
| Level Length: | (If available) 9 |




Scroll down and press start.

For each level, you receive 15 lives. If you die, you can try again from the start. If you die in the same level twice, please use ESC -> main menu to exit. If this is the case, please state this in the open comment section of the questionnaire. This also applies to trial 2 and 3.

After completing the level. Please fill out the second section of the questionnaire (Titled Trial 1).

# Step 8: Trial 2

Repeat step 7 but with a different condition. Please enter the following values in the main menu:

| **Trial 2** | |
|---|---|
| **Participant number** | **Condition** |
| 1 | B |
| 2 | C |
| 3 | B |
| 4 | C |
| 5 | A |
| 6 | A |

| | |
|---|---|
| Selection Seed: | 7848 |
| Shuffler Seed: | 59 |
| Generation Type: | [YOUR CONDITION] |
| Level Type: | Cave Area |
| Level Length: | (If available) 9 |


Scroll down and press start.

After completing the level. Please fill out the third section of the questionnaire (Titled Trial 2).

# Step 9: Trial 3

Repeat step 7 but with a different condition. Please enter the following values in the main menu:

| **Trial 3** | |
|---|---|
| **Participant number** | **Condition** |
| 1 | A |
| 2 | A |
| 3 | C |
| 4 | B |
| 5 | B |
| 6 | C |

| | |
|---|---|
| Selection Seed: | 7848 |
| Shuffler Seed: | 59 |
| Generation Type: | [YOUR CONDITION] |
| Level Type: | Cave Area |
| Level Length: | (If available) 9 |


Scroll down and press start.

After completing the level. Please fill out the fourth and final section of the questionnaire (Titled Trial 3). Please submit your questionnaire after this.

# Step 10: Finishing up

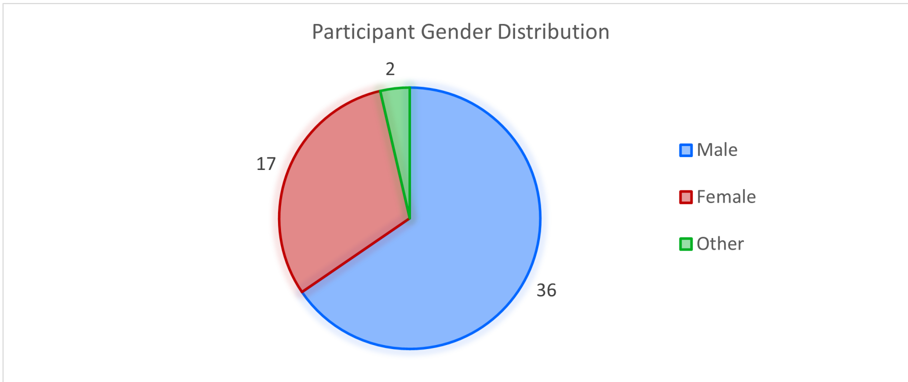
This was the last trial. You completed the experiment. Use ALT + F4 to close the game.

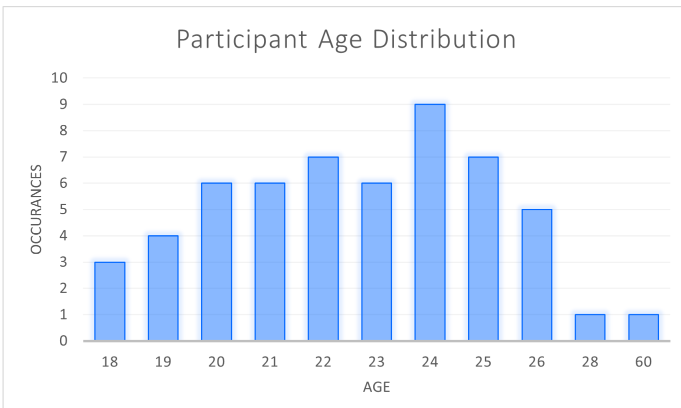
Thank you for your participation. You're allowed to keep the game if you want.

# Withdrawing from the study

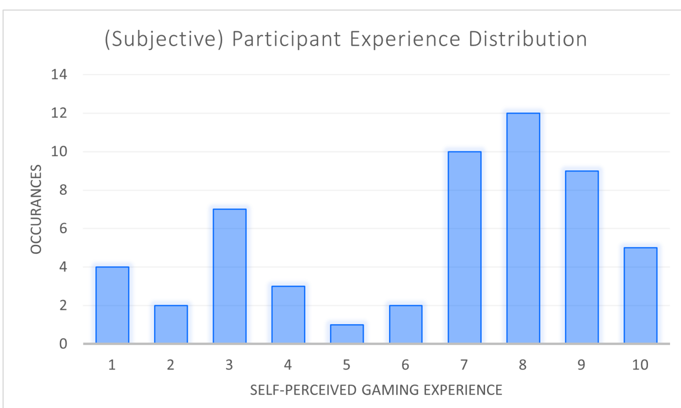
If you have any questions regarding this study, or wish to withdraw your data, this is possible until 24-11-2022, by contacting me via https://www.joepeijkemans.nl/#contact. You will need the same e-mail address that you entered in the questionnaire as an identifier.

## Appendix C: Demographic data visualized




Mean: 23.182
Mode: 24
Median: 23




Mean: 6.455
Mode: 8
Median: 7

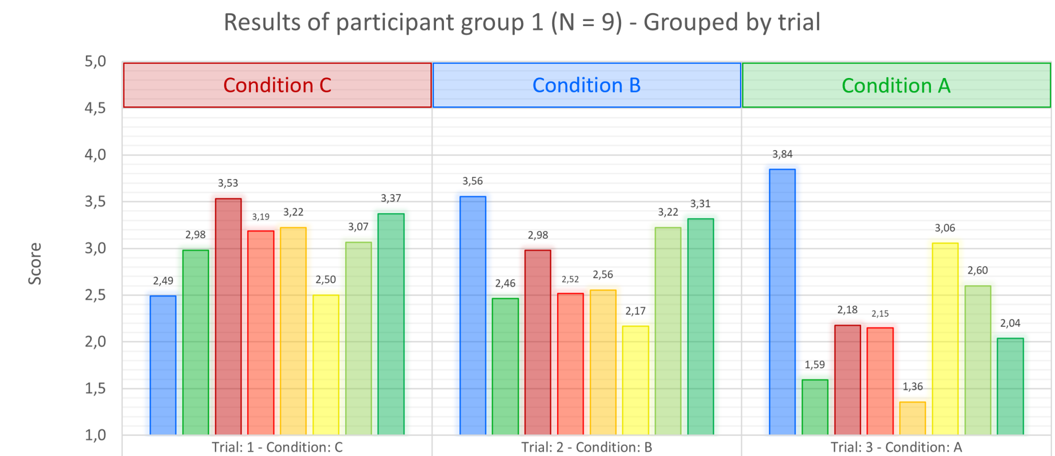
Table 14: The demographic data of the participants visualized. See Section 8.1 for elaboration or Appendix D for the raw data.

## Appendix D: Demographic data

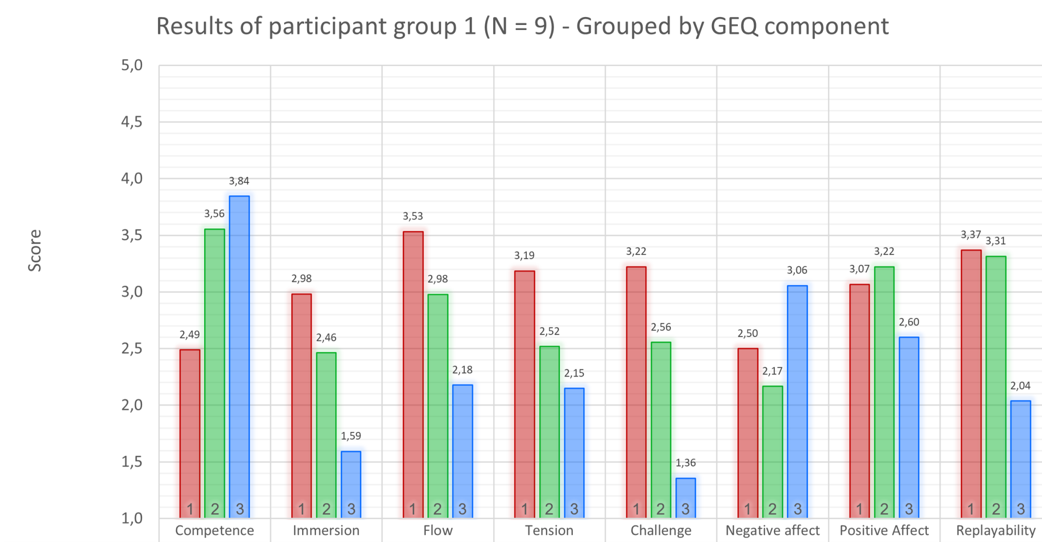
| PID | P Num | Age | Gender | Experience |
|---|---|---|---|---|
| 1 | 3 | 22 | Male | 4 |
| 2 | 4 | 25 | Male | 7 |
| 3 | 5 | 20 | Female | 7 |
| 4 | 6 | 22 | Female | 3 |
| 5 | 3 | 25 | Male | 7 |
| 6 | 2 | 22 | Female | 2 |
| 7 | 4 | 21 | Male | 10 |
| 8 | 5 | 25 | Female | 3 |
| 9 | 1 | 24 | Male | 9 |
| 10 | 2 | 25 | Male | 8 |
| 11 | 3 | 24 | Other | 8 |
| 12 | 4 | 23 | Female | 6 |
| 13 | 6 | 25 | Male | 9 |
| 14 | 2 | 28 | Male | 8 |
| 15 | 2 | 19 | Male | 9 |
| 16 | 5 | 23 | Female | 1 |
| 17 | 3 | 20 | Other | 10 |
| 18 | 1 | 26 | Female | 6 |
| 19 | 4 | 21 | Female | 3 |
| 20 | 5 | 22 | Male | 8 |
| 21 | 6 | 23 | Female | 3 |
| 22 | 1 | 24 | Male | 8 |
| 23 | 3 | 20 | Male | 9 |
| 24 | 4 | 22 | Male | 3 |
| 25 | 2 | 19 | Male | 9 |
| 26 | 5 | 26 | Male | 7 |
| 27 | 6 | 26 | Female | 5 |
| 28 | 1 | 24 | Male | 8 |
| 29 | 2 | 21 | Male | 9 |
| 30 | 6 | 20 | Male | 8 |
| 31 | 2 | 21 | Male | 7 |
| 32 | 1 | 23 | Female | 3 |
| 33 | 3 | 23 | Female | 4 |
| 34 | 4 | 18 | Male | 10 |
| 35 | 5 | 19 | Male | 9 |
| 36 | 1 | 22 | Male | 3 |
| 37 | 6 | 21 | Male | 8 |
| 38 | 3 | 24 | Male | 8 |
| 39 | 1 | 18 | Female | 8 |
| 40 | 4 | 24 | Male | 7 |
| 41 | 5 | 19 | Female | 2 |
| 42 | 6 | 24 | Male | 10 |
| 43 | 3 | 25 | Male | 7 |
| 44 | 4 | 26 | Male | 7 |
| 45 | 5 | 20 | Male | 9 |
| 46 | 6 | 24 | Male | 7 |
| 47 | 2 | 24 | Male | 8 |
| 48 | 6 | 18 | Male | 9 |
| 49 | 1 | 21 | Female | 1 |
| 50 | 2 | 23 | Male | 8 |
| 51 | 3 | 25 | Male | 10 |
| 52 | 4 | 60 | Male | 4 |
| 53 | 1 | 20 | Female | 1 |
| 54 | 5 | 26 | Female | 1 |
| 55 | 4 | 22 | Male | 7 |

Table 15: Demographic data of the participants. PID is used as an unique identifier for each participant. See Section 8.1 for elaboration or Appendix C for a visualisation of this data.

## Appendix E: GEQ data visualized

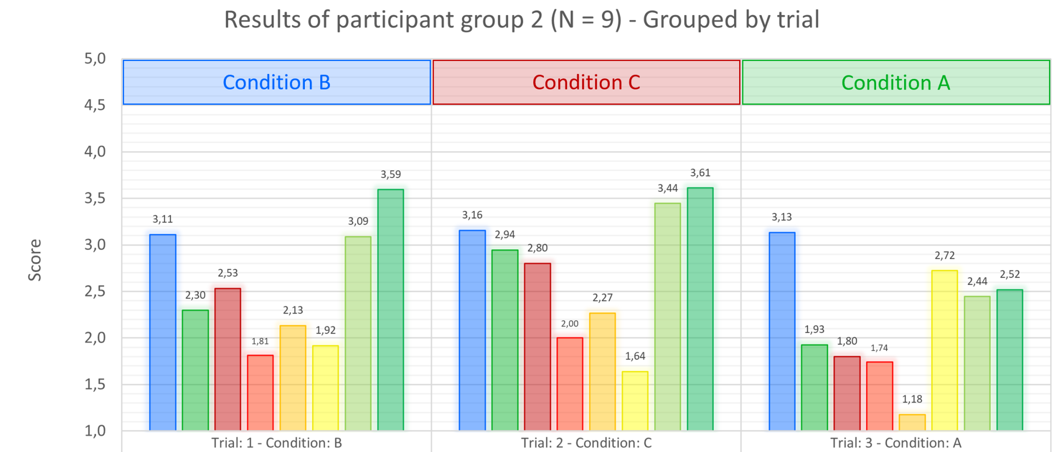



| | Trial: 1 - Condition: C | Trial: 2 - Condition: B | Trial: 3 - Condition: A |
|---|---|---|---|
| Competence | 2,489 | 3,556 | 3,844 |
| Immersion | 2,981 | 2,463 | 1,593 |
| Flow | 3,533 | 2,978 | 2,178 |
| Tension | 3,185 | 2,519 | 2,148 |
| Challenge | 3,222 | 2,556 | 1,356 |
| Negative affect | 2,500 | 2,167 | 3,056 |
| Positive Affect | 3,067 | 3,222 | 2,600 |
| Replayability | 3,370 | 3,315 | 2,037 |

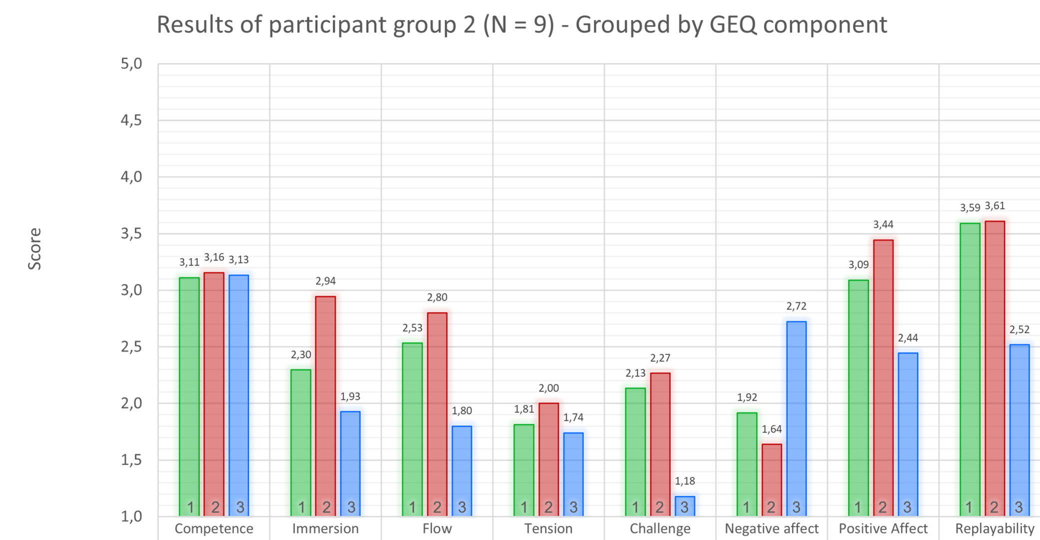



| | Competence | Immersion | Flow | Tension | Challenge | Negative affect | Positive Affect | Replayability |
|---|---|---|---|---|---|---|---|---|
| Trial: 1 - Condition: C | 2,489 | 2,981 | 3,533 | 3,185 | 3,222 | 2,500 | 3,067 | 3,370 |
| Trial: 2 - Condition: B | 3,556 | 2,463 | 2,978 | 2,519 | 2,556 | 2,167 | 3,222 | 3,315 |
| Trial: 3 - Condition: A | 3,844 | 1,593 | 2,178 | 2,148 | 1,356 | 3,056 | 2,600 | 2,037 |

Figure 6: The results of participant group 1 (Condition order C, B, A) sorted by trial and by GEQ component. Note that the colors refer to the conditions in the lower graph (Condition A = blue, B = green, C = red)

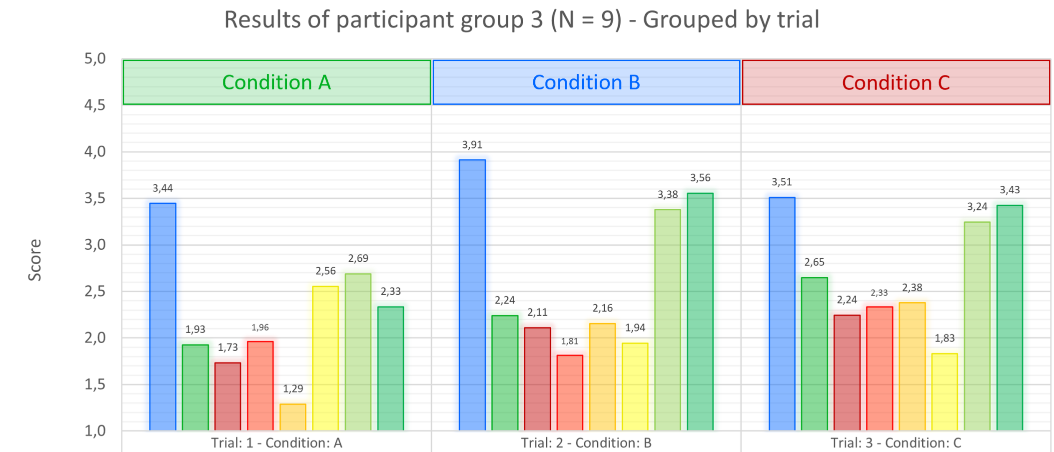



| | Trial: 1 - Condition: B | Trial: 2 - Condition: C | Trial: 3 - Condition: A |
|---|---|---|---|
| Competence | 3,111 | 3,156 | 3,133 |
| Immersion | 2,296 | 2,944 | 1,926 |
| Flow | 2,533 | 2,800 | 1,800 |
| Tension | 1,815 | 2,000 | 1,741 |
| Challenge | 2,133 | 2,267 | 1,178 |
| Negative affect | 1,917 | 1,639 | 2,722 |
| Positive Affect | 3,089 | 3,444 | 2,444 |
| Replayability | 3,593 | 3,611 | 2,519 |

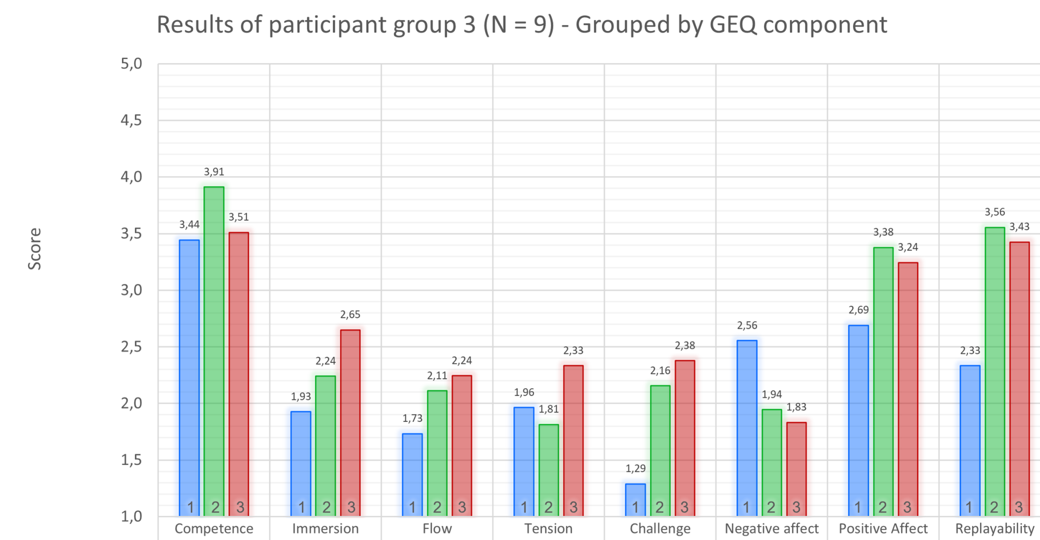



| | Competence | Immersion | Flow | Tension | Challenge | Negative affect | Positive Affect | Replayability |
|---|---|---|---|---|---|---|---|---|
| Trial: 1 - Condition: B | 3,111 | 2,296 | 2,533 | 1,815 | 2,133 | 1,917 | 3,089 | 3,593 |
| Trial: 2 - Condition: C | 3,156 | 2,944 | 2,800 | 2,000 | 2,267 | 1,639 | 3,444 | 3,611 |
| Trial: 3 - Condition: A | 3,133 | 1,926 | 1,800 | 1,741 | 1,178 | 2,722 | 2,444 | 2,519 |

Figure 7: The results of participant group 2 (Condition order B, C, A) sorted by trial and by GEQ component. Note that the colors refer to the conditions in the lower graph (Condition A = blue, B = green, C = red)

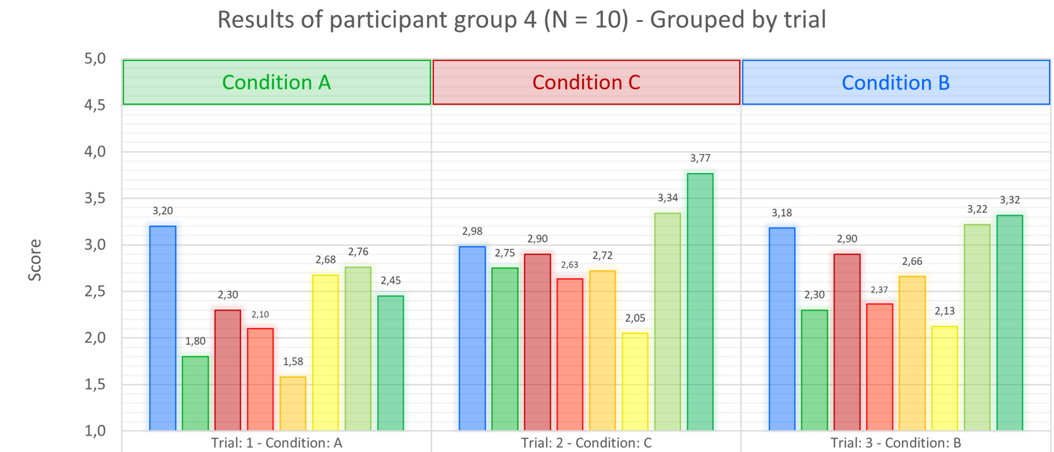



| | Trial: 1 - Condition: A | Trial: 2 - Condition: B | Trial: 3 - Condition: C |
|---|---|---|---|
| Competence | 3,444 | 3,911 | 3,511 |
| Immersion | 1,926 | 2,241 | 2,648 |
| Flow | 1,733 | 2,111 | 2,244 |
| Tension | 1,963 | 1,815 | 2,333 |
| Challenge | 1,289 | 2,156 | 2,378 |
| Negative affect | 2,556 | 1,944 | 1,833 |
| Positive Affect | 2,689 | 3,378 | 3,244 |
| Replayability | 2,333 | 3,556 | 3,426 |

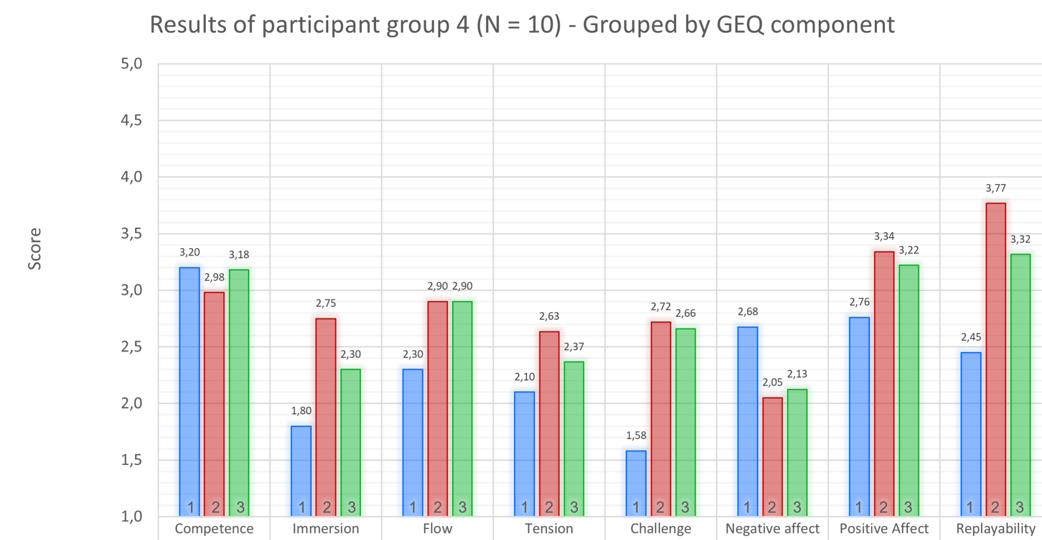



| | Competence | Immersion | Flow | Tension | Challenge | Negative affect | Positive Affect | Replayability |
|---|---|---|---|---|---|---|---|---|
| Trial: 1 - Condition: A | 3,444 | 1,926 | 1,733 | 1,963 | 1,289 | 2,556 | 2,689 | 2,333 |
| Trial: 2 - Condition: B | 3,911 | 2,241 | 2,111 | 1,815 | 2,156 | 1,944 | 3,378 | 3,556 |
| Trial: 3 - Condition: C | 3,511 | 2,648 | 2,244 | 2,333 | 2,378 | 1,833 | 3,244 | 3,426 |

Figure 8: The results of participant group 3 (Condition order A, B, C) sorted by trial and by GEQ component. Note that the colors refer to the conditions in the lower graph (Condition A = blue, B = green, C = red)

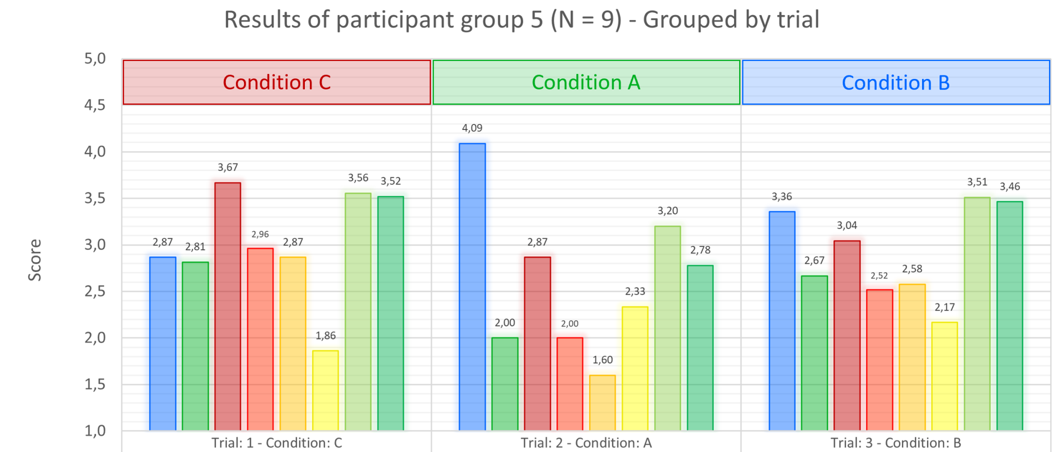



| | Trial: 1 - Condition: A | Trial: 2 - Condition: C | Trial: 3 - Condition: B |
|---|---|---|---|
| Competence | 3,200 | 2,980 | 3,180 |
| Immersion | 1,800 | 2,750 | 2,300 |
| Flow | 2,300 | 2,900 | 2,900 |
| Tension | 2,100 | 2,633 | 2,367 |
| Challenge | 1,580 | 2,720 | 2,660 |
| Negative affect | 2,675 | 2,050 | 2,125 |
| Positive Affect | 2,760 | 3,340 | 3,220 |
| Replayability | 2,450 | 3,767 | 3,317 |

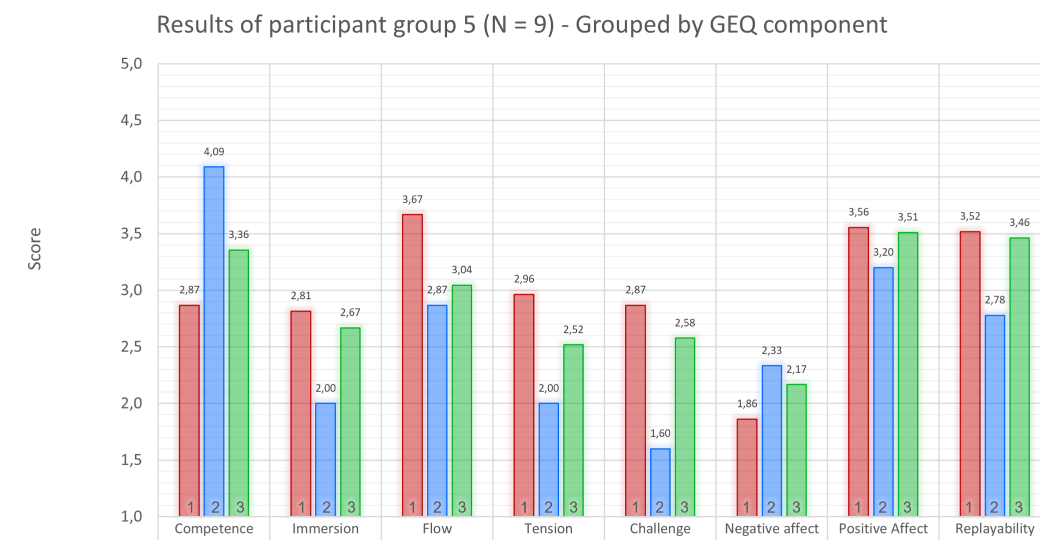



| | Competence | Immersion | Flow | Tension | Challenge | Negative affect | Positive Affect | Replayability |
|---|---|---|---|---|---|---|---|---|
| Trial: 1 - Condition: A | 3,200 | 1,800 | 2,300 | 2,100 | 1,580 | 2,675 | 2,760 | 2,450 |
| Trial: 2 - Condition: C | 2,980 | 2,750 | 2,900 | 2,633 | 2,720 | 2,050 | 3,340 | 3,767 |
| Trial: 3 - Condition: B | 3,180 | 2,300 | 2,900 | 2,367 | 2,660 | 2,125 | 3,220 | 3,317 |

Figure 9: The results of participant group 4 (Condition order A, C, B) sorted by trial and by GEQ component. Note that the colors refer to the conditions in the lower graph (Condition A = blue, B = green, C = red)

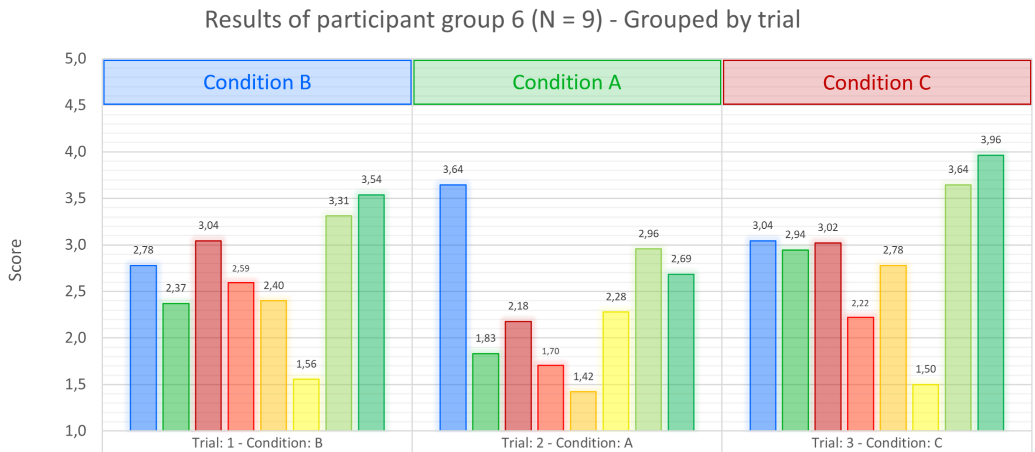



| | Trial: 1 - Condition: C | Trial: 2 - Condition: A | Trial: 3 - Condition: B |
|---|---|---|---|
| Competence | 2,867 | 4,089 | 3,356 |
| Immersion | 2,815 | 2,000 | 2,667 |
| Flow | 3,667 | 2,867 | 3,044 |
| Tension | 2,963 | 2,000 | 2,519 |
| Challenge | 2,867 | 1,600 | 2,578 |
| Negative affect | 1,861 | 2,333 | 2,167 |
| Positive Affect | 3,556 | 3,200 | 3,511 |
| Replayability | 3,519 | 2,778 | 3,463 |

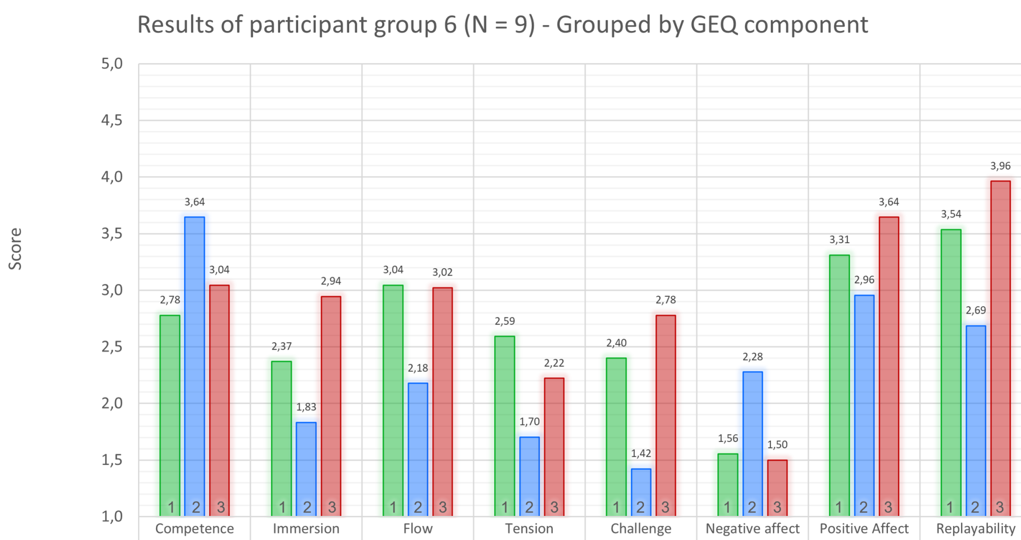



| | Competence | Immersion | Flow | Tension | Challenge | Negative affect | Positive Affect | Replayability |
|---|---|---|---|---|---|---|---|---|
| Trial: 1 - Condition: C | 2,867 | 2,815 | 3,667 | 2,963 | 2,867 | 1,861 | 3,556 | 3,519 |
| Trial: 2 - Condition: A | 4,089 | 2,000 | 2,867 | 2,000 | 1,600 | 2,333 | 3,200 | 2,778 |
| Trial: 3 - Condition: B | 3,356 | 2,667 | 3,044 | 2,519 | 2,578 | 2,167 | 3,511 | 3,463 |

Figure 10: The results of participant group 5 (Condition order C, A, B) sorted by trial and by GEQ component. Note that the colors refer to the conditions in the lower graph (Condition A = blue, B = green, C = red)




| | Trial: 1 - Condition: B | Trial: 2 - Condition: A | Trial: 3 - Condition: C |
|---|---|---|---|
| Competence | 2,778 | 3,644 | 3,044 |
| Immersion | 2,370 | 1,833 | 2,944 |
| Flow | 3,044 | 2,178 | 3,022 |
| Tension | 2,593 | 1,704 | 2,222 |
| Challenge | 2,400 | 1,422 | 2,778 |
| Negative affect | 1,556 | 2,278 | 1,500 |
| Positive Affect | 3,311 | 2,956 | 3,644 |
| Replayability | 3,537 | 2,685 | 3,963 |




| | Competence | Immersion | Flow | Tension | Challenge | Negative affect | Positive Affect | Replayability |
|---|---|---|---|---|---|---|---|---|
| Trial: 1 - Condition: B | 2,778 | 2,370 | 3,044 | 2,593 | 2,400 | 1,556 | 3,311 | 3,537 |
| Trial: 2 - Condition: A | 3,644 | 1,833 | 2,178 | 1,704 | 1,422 | 2,278 | 2,956 | 2,685 |
| Trial: 3 - Condition: C | 3,044 | 2,944 | 3,022 | 2,222 | 2,778 | 1,500 | 3,644 | 3,963 |

Figure 11: The results of participant group 6 (Condition order B, A, C) sorted by trial and by GEQ component. Note that the colors refer to the conditions in the lower graph (Condition A = blue, B = green, C = red)

## Appendix F: GEQ data

| Participant ID | Trial | Condition | Competence | Immersion | Flow | Tension | Challenge | Negative Affect | Positive Affect | Replayability |
|---|---|---|---|---|---|---|---|---|---|---|
| 9 | 1 | C | 3.20 | 1.67 | 2.20 | 3.67 | 1.80 | 4.00 | 2.00 | 1.17 |
| 18 | 1 | C | 4.00 | 3.00 | 3.40 | 1.67 | 2.40 | 1.25 | 4.00 | 4.50 |
| 22 | 1 | C | 3.20 | 3.17 | 4.40 | 4.33 | 3.80 | 2.00 | 3.20 | 3.67 |
| 28 | 1 | C | 3.40 | 2.67 | 4.00 | 2.33 | 3.20 | 1.75 | 3.40 | 3.67 |
| 32 | 1 | C | 1.20 | 3.83 | 4.20 | 3.67 | 3.40 | 2.75 | 2.80 | 3.67 |
| 36 | 1 | C | 1.00 | 3.17 | 3.80 | 4.67 | 4.00 | 2.50 | 3.00 | 4.00 |
| 39 | 1 | C | 3.20 | 2.83 | 3.60 | 4.33 | 4.20 | 2.75 | 3.60 | 4.17 |
| 49 | 1 | C | 1.00 | 2.83 | 3.20 | 2.33 | 3.20 | 3.25 | 2.00 | 2.17 |
| 53 | 1 | C | 2.20 | 3.67 | 3.00 | 1.67 | 3.00 | 2.25 | 3.60 | 3.33 |
| 9 | 2 | B | 3.60 | 1.33 | 2.00 | 4.00 | 1.40 | 3.75 | 1.80 | 1.00 |
| 18 | 2 | B | 4.00 | 1.67 | 2.20 | 1.33 | 2.20 | 1.75 | 3.00 | 4.00 |
| 22 | 2 | B | 4.40 | 2.67 | 1.80 | 1.00 | 1.00 | 1.75 | 3.00 | 3.33 |
| 28 | 2 | B | 4.00 | 2.17 | 4.00 | 1.00 | 1.60 | 1.75 | 4.00 | 3.83 |
| 32 | 2 | B | 4.60 | 3.67 | 4.80 | 2.33 | 2.40 | 1.25 | 4.40 | 3.83 |
| 36 | 2 | B | 3.80 | 2.83 | 4.40 | 3.00 | 3.40 | 1.25 | 4.40 | 4.50 |
| 39 | 2 | B | 4.40 | 2.50 | 2.00 | 2.67 | 4.40 | 2.75 | 3.80 | 3.67 |
| 49 | 2 | B | 1.00 | 2.17 | 3.00 | 4.67 | 3.80 | 3.00 | 1.20 | 2.33 |
| 53 | 2 | B | 2.20 | 3.17 | 2.60 | 2.67 | 2.80 | 2.25 | 3.40 | 3.33 |
| 9 | 3 | A | 4.20 | 1.00 | 1.60 | 4.67 | 1.20 | 4.50 | 1.00 | 1.00 |
| 18 | 3 | A | 3.80 | 1.33 | 1.60 | 2.33 | 1.00 | 2.75 | 2.60 | 2.00 |
| 22 | 3 | A | 2.60 | 1.00 | 1.00 | 1.67 | 1.00 | 3.00 | 1.20 | 2.17 |
| 28 | 3 | A | 4.40 | 1.67 | 1.80 | 1.67 | 1.00 | 2.50 | 2.40 | 1.50 |
| 32 | 3 | A | 4.60 | 2.67 | 3.80 | 2.33 | 2.00 | 2.50 | 3.80 | 3.33 |
| 36 | 3 | A | 5.00 | 2.17 | 3.40 | 1.00 | 1.80 | 2.50 | 4.40 | 2.83 |
| 39 | 3 | A | 3.60 | 1.17 | 1.60 | 3.33 | 1.80 | 4.50 | 2.60 | 2.00 |
| 49 | 3 | A | 2.60 | 1.67 | 3.20 | 1.33 | 1.00 | 3.00 | 2.80 | 1.17 |
| 53 | 3 | A | 3.80 | 1.67 | 1.60 | 1.00 | 1.40 | 2.25 | 2.60 | 2.33 |

Table 16: Questionnaire results of participant group 1 (N = 9)

| Participant ID | Trial | Condition | Competence | Immersion | Flow | Tension | Challenge | Negative Affect | Positive Affect | Replayability |
|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 1 | B | 3.40 | 3.83 | 3.80 | 1.33 | 2.60 | 1.25 | 5.00 | 4.17 |
| 10 | 1 | B | 4.20 | 3.50 | 4.20 | 1.00 | 2.20 | 1.00 | 4.40 | 4.33 |
| 14 | 1 | B | 3.20 | 1.17 | 1.20 | 1.00 | 1.20 | 1.75 | 2.00 | 3.00 |
| 15 | 1 | B | 1.40 | 1.50 | 2.00 | 3.33 | 2.20 | 2.50 | 1.20 | 3.00 |
| 25 | 1 | B | 2.20 | 1.00 | 1.00 | 1.67 | 1.40 | 3.75 | 2.20 | 2.83 |
| 29 | 1 | B | 4.00 | 3.83 | 3.00 | 1.33 | 3.20 | 1.00 | 4.00 | 4.67 |
| 31 | 1 | B | 4.40 | 2.67 | 2.80 | 2.00 | 1.60 | 2.50 | 3.40 | 3.17 |
| 47 | 1 | B | 2.80 | 1.33 | 3.00 | 3.33 | 2.00 | 2.25 | 3.40 | 3.50 |
| 50 | 1 | B | 2.40 | 1.83 | 1.80 | 1.33 | 2.80 | 1.25 | 2.20 | 3.67 |
| 6 | 2 | C | 3.20 | 4.33 | 3.60 | 2.00 | 2.60 | 1.25 | 5.00 | 4.33 |
| 10 | 2 | C | 4.40 | 4.33 | 3.60 | 1.00 | 1.40 | 1.00 | 4.40 | 4.33 |
| 14 | 2 | C | 3.20 | 1.17 | 1.00 | 1.00 | 1.40 | 1.75 | 2.40 | 3.50 |
| 15 | 2 | C | 3.80 | 4.17 | 3.80 | 1.67 | 3.20 | 1.25 | 4.00 | 4.67 |
| 25 | 2 | C | 1.40 | 1.50 | 1.00 | 3.67 | 1.60 | 3.00 | 1.60 | 1.83 |
| 29 | 2 | C | 4.00 | 3.83 | 3.20 | 1.00 | 2.60 | 1.00 | 4.00 | 4.00 |
| 31 | 2 | C | 2.40 | 3.50 | 3.40 | 4.00 | 3.20 | 3.25 | 2.80 | 2.67 |
| 47 | 2 | C | 3.00 | 1.50 | 3.20 | 1.33 | 1.80 | 1.25 | 3.80 | 3.00 |
| 50 | 2 | C | 3.00 | 2.17 | 2.40 | 2.33 | 2.60 | 1.00 | 3.00 | 4.17 |
| 6 | 3 | A | 3.00 | 4.00 | 3.20 | 1.33 | 2.00 | 1.25 | 4.60 | 4.67 |
| 10 | 3 | A | 3.20 | 2.50 | 1.60 | 2.00 | 1.00 | 2.75 | 2.20 | 2.50 |
| 14 | 3 | A | 2.60 | 2.00 | 1.40 | 1.00 | 1.60 | 1.25 | 2.60 | 4.00 |
| 15 | 3 | A | 2.40 | 1.17 | 1.00 | 2.00 | 1.00 | 4.00 | 1.20 | 1.50 |
| 25 | 3 | A | 2.60 | 1.00 | 1.00 | 1.00 | 1.00 | 3.25 | 1.60 | 1.50 |
| 29 | 3 | A | 4.00 | 3.17 | 2.20 | 1.33 | 1.00 | 2.50 | 3.60 | 2.33 |
| 31 | 3 | A | 5.00 | 1.33 | 1.60 | 4.67 | 1.00 | 4.25 | 2.20 | 1.67 |
| 47 | 3 | A | 2.40 | 1.00 | 3.20 | 1.33 | 1.00 | 3.25 | 2.40 | 2.00 |
| 50 | 3 | A | 3.00 | 1.17 | 1.00 | 1.00 | 1.00 | 2.00 | 1.60 | 2.50 |

Table 17: Questionnaire results of participant group 2 (N = 9)

| Participant ID | Trial | Condition | Competence | Immersion | Flow | Tension | Challenge | Negative Affect | Positive Affect | Replayability |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | A | 3.40 | 1.83 | 2.20 | 1.00 | 1.00 | 1.25 | 3.60 | 3.67 |
| 5 | 1 | A | 2.80 | 2.83 | 1.80 | 2.33 | 1.20 | 2.75 | 2.60 | 2.00 |
| 11 | 1 | A | 3.60 | 1.50 | 1.60 | 3.33 | 1.20 | 3.50 | 1.80 | 1.50 |
| 17 | 1 | A | 3.20 | 1.67 | 1.40 | 3.33 | 1.20 | 3.50 | 3.00 | 2.00 |
| 23 | 1 | A | 3.20 | 1.33 | 1.00 | 1.00 | 1.00 | 3.75 | 1.60 | 1.67 |
| 33 | 1 | A | 3.60 | 1.50 | 1.80 | 1.33 | 1.00 | 2.75 | 1.80 | 2.17 |
| 38 | 1 | A | 4.00 | 1.33 | 1.40 | 2.00 | 1.00 | 2.50 | 3.00 | 2.67 |
| 43 | 1 | A | 4.00 | 3.33 | 2.60 | 1.67 | 2.40 | 1.00 | 3.60 | 2.50 |
| 51 | 1 | A | 3.20 | 2.00 | 1.80 | 1.67 | 1.60 | 2.00 | 3.20 | 2.83 |
| 1 | 2 | B | 4.20 | 2.00 | 2.20 | 1.00 | 3.00 | 1.00 | 4.20 | 4.00 |
| 5 | 2 | B | 4.20 | 3.50 | 2.60 | 1.67 | 2.40 | 1.75 | 3.80 | 3.67 |
| 11 | 2 | B | 4.40 | 1.17 | 1.20 | 2.00 | 1.20 | 3.50 | 1.80 | 1.50 |
| 17 | 2 | B | 3.20 | 1.50 | 2.00 | 3.00 | 2.20 | 3.50 | 3.00 | 3.50 |
| 23 | 2 | B | 4.00 | 1.17 | 1.00 | 1.67 | 1.40 | 1.50 | 2.80 | 3.33 |
| 33 | 2 | B | 3.00 | 1.50 | 2.80 | 1.67 | 1.60 | 1.25 | 2.80 | 4.00 |
| 38 | 2 | B | 5.00 | 2.83 | 2.00 | 1.33 | 1.80 | 1.50 | 4.20 | 4.33 |
| 43 | 2 | B | 3.20 | 3.50 | 2.40 | 2.00 | 3.00 | 2.00 | 3.80 | 3.83 |
| 51 | 2 | B | 4.00 | 3.00 | 2.80 | 2.00 | 2.80 | 1.50 | 4.00 | 3.83 |
| 1 | 3 | C | 3.00 | 2.17 | 2.80 | 1.00 | 2.60 | 1.25 | 4.40 | 4.17 |
| 5 | 3 | C | 4.60 | 4.50 | 3.20 | 2.00 | 2.40 | 1.00 | 4.40 | 4.50 |
| 11 | 3 | C | 4.40 | 1.33 | 1.20 | 2.00 | 1.00 | 3.00 | 2.00 | 1.83 |
| 17 | 3 | C | 2.80 | 2.50 | 1.60 | 3.00 | 1.20 | 2.25 | 2.40 | 2.33 |
| 23 | 3 | C | 3.40 | 1.50 | 1.00 | 1.67 | 1.60 | 1.50 | 2.20 | 3.00 |
| 33 | 3 | C | 2.40 | 1.67 | 2.20 | 3.67 | 3.00 | 2.00 | 2.20 | 3.00 |
| 38 | 3 | C | 5.00 | 2.83 | 2.80 | 1.33 | 3.00 | 1.75 | 4.00 | 4.33 |
| 43 | 3 | C | 2.20 | 3.83 | 2.60 | 3.67 | 3.60 | 2.50 | 3.60 | 3.67 |
| 51 | 3 | C | 3.80 | 3.50 | 2.80 | 2.67 | 3.00 | 1.25 | 4.00 | 4.00 |

Table 18: Questionnaire results of participant group 3 (N = 9)

| Participant ID | Trial | Condition | Competence | Immersion | Flow | Tension | Challenge | Negative Affect | Positive Affect | Replayability |
|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 1 | A | 3.80 | 1.17 | 2.00 | 2.33 | 1.40 | 3.00 | 3.00 | 3.00 |
| 7 | 1 | A | 3.40 | 1.00 | 1.00 | 1.00 | 1.00 | 2.50 | 1.80 | 1.33 |
| 12 | 1 | A | 4.00 | 2.50 | 3.40 | 1.00 | 1.40 | 1.75 | 4.20 | 3.33 |
| 19 | 1 | A | 3.80 | 1.33 | 1.20 | 2.33 | 1.00 | 4.50 | 2.00 | 1.17 |
| 24 | 1 | A | 2.40 | 1.17 | 1.80 | 3.33 | 1.00 | 3.25 | 2.00 | 2.33 |
| 34 | 1 | A | 3.00 | 1.17 | 1.00 | 1.00 | 1.00 | 3.25 | 1.80 | 1.00 |
| 40 | 1 | A | 4.80 | 2.33 | 2.80 | 1.00 | 1.00 | 2.00 | 4.40 | 3.33 |
| 44 | 1 | A | 2.00 | 3.00 | 3.20 | 2.67 | 3.00 | 1.75 | 3.20 | 3.50 |
| 52 | 1 | A | 1.80 | 2.50 | 3.80 | 3.00 | 3.00 | 2.25 | 2.60 | 3.50 |
| 55 | 1 | A | 3.00 | 1.83 | 2.80 | 3.33 | 2.00 | 2.50 | 2.60 | 2.00 |
| 2 | 2 | C | 4.00 | 3.33 | 3.00 | 2.00 | 2.80 | 1.75 | 4.40 | 4.50 |
| 7 | 2 | C | 2.60 | 1.33 | 1.00 | 1.00 | 1.00 | 3.25 | 2.20 | 1.83 |
| 12 | 2 | C | 1.40 | 2.33 | 2.80 | 4.67 | 2.80 | 2.00 | 2.40 | 3.50 |
| 19 | 2 | C | 3.00 | 4.00 | 3.40 | 1.67 | 2.60 | 1.25 | 4.40 | 4.67 |
| 24 | 2 | C | 3.40 | 1.50 | 2.80 | 3.67 | 2.40 | 2.50 | 3.40 | 4.00 |
| 34 | 2 | C | 5.00 | 3.17 | 3.20 | 1.67 | 2.20 | 1.25 | 4.60 | 5.00 |
| 40 | 2 | C | 5.00 | 3.50 | 3.20 | 1.00 | 2.20 | 1.00 | 4.60 | 4.00 |
| 44 | 2 | C | 1.40 | 2.50 | 2.80 | 2.67 | 3.40 | 1.75 | 2.80 | 4.17 |
| 52 | 2 | C | 1.00 | 3.00 | 4.00 | 4.00 | 4.20 | 2.50 | 2.00 | 3.33 |
| 55 | 2 | C | 3.00 | 2.83 | 2.80 | 4.00 | 3.60 | 3.25 | 2.60 | 2.67 |
| 2 | 3 | B | 3.80 | 2.50 | 2.40 | 3.00 | 3.00 | 2.75 | 4.20 | 4.00 |
| 7 | 3 | B | 2.60 | 1.00 | 1.00 | 1.00 | 1.00 | 2.75 | 1.60 | 2.17 |
| 12 | 3 | B | 3.00 | 2.67 | 3.40 | 2.00 | 2.20 | 1.00 | 4.00 | 4.00 |
| 19 | 3 | B | 3.00 | 2.83 | 3.00 | 2.00 | 2.80 | 1.50 | 3.80 | 4.67 |
| 24 | 3 | B | 2.60 | 1.17 | 1.00 | 1.67 | 1.00 | 2.50 | 2.20 | 2.00 |
| 34 | 3 | B | 5.00 | 2.00 | 5.00 | 2.33 | 3.80 | 1.75 | 5.00 | 4.00 |
| 40 | 3 | B | 5.00 | 2.00 | 2.40 | 1.00 | 1.40 | 1.75 | 4.20 | 3.00 |
| 44 | 3 | B | 1.40 | 3.33 | 3.60 | 4.00 | 4.20 | 2.25 | 1.40 | 3.50 |
| 52 | 3 | B | 1.00 | 2.00 | 3.80 | 5.00 | 4.40 | 3.25 | 1.00 | 2.17 |
| 55 | 3 | B | 4.40 | 3.50 | 3.40 | 1.67 | 2.80 | 1.75 | 4.80 | 3.67 |

Table 19: Questionnaire results of participant group 4 (N = 10)

| Participant ID | Trial | Condition | Competence | Immersion | Flow | Tension | Challenge | Negative Affect | Positive Affect | Replayability |
|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 1 | C | 2.40 | 2.50 | 3.00 | 3.33 | 3.00 | 1.25 | 4.20 | 3.33 |
| 8 | 1 | C | 4.20 | 4.67 | 4.20 | 2.00 | 2.20 | 1.75 | 5.00 | 4.50 |
| 16 | 1 | C | 1.80 | 2.50 | 3.80 | 3.33 | 3.60 | 1.75 | 2.60 | 3.33 |
| 20 | 1 | C | 2.60 | 3.83 | 4.20 | 2.00 | 2.80 | 1.25 | 4.40 | 4.33 |
| 26 | 1 | C | 2.00 | 2.50 | 2.60 | 3.67 | 2.60 | 2.75 | 2.80 | 2.67 |
| 35 | 1 | C | 4.00 | 3.00 | 4.00 | 1.33 | 2.00 | 1.25 | 4.00 | 4.00 |
| 41 | 1 | C | 1.00 | 1.50 | 2.60 | 5.00 | 4.00 | 3.25 | 1.00 | 2.17 |
| 45 | 1 | C | 4.80 | 2.17 | 4.00 | 1.33 | 1.80 | 1.50 | 4.00 | 3.17 |
| 54 | 1 | C | 3.00 | 2.67 | 4.60 | 4.67 | 3.80 | 2.00 | 4.00 | 4.17 |
| 3 | 2 | A | 4.00 | 2.17 | 2.80 | 1.00 | 1.00 | 1.25 | 4.60 | 4.17 |
| 8 | 2 | A | 5.00 | 3.50 | 4.80 | 1.33 | 1.00 | 1.25 | 3.80 | 4.50 |
| 16 | 2 | A | 4.80 | 2.00 | 3.40 | 2.00 | 2.20 | 2.25 | 4.80 | 3.00 |
| 20 | 2 | A | 3.00 | 1.00 | 1.00 | 3.33 | 1.00 | 3.75 | 1.60 | 1.67 |
| 26 | 2 | A | 4.40 | 2.17 | 1.80 | 2.33 | 1.60 | 4.00 | 1.80 | 1.17 |
| 35 | 2 | A | 3.80 | 1.67 | 2.00 | 1.33 | 1.00 | 2.00 | 2.20 | 2.67 |
| 41 | 2 | A | 4.40 | 1.33 | 1.20 | 1.67 | 1.20 | 2.50 | 3.00 | 2.00 |
| 45 | 2 | A | 4.40 | 2.00 | 3.80 | 1.67 | 1.00 | 2.25 | 3.00 | 2.33 |
| 54 | 2 | A | 3.00 | 2.17 | 5.00 | 3.33 | 4.40 | 1.75 | 4.00 | 3.50 |
| 3 | 3 | B | 2.20 | 3.00 | 2.20 | 4.33 | 3.60 | 2.00 | 2.80 | 3.33 |
| 8 | 3 | B | 4.60 | 3.83 | 4.20 | 1.00 | 1.80 | 1.00 | 5.00 | 4.83 |
| 16 | 3 | B | 4.00 | 3.33 | 4.00 | 3.00 | 3.20 | 1.25 | 4.00 | 4.17 |
| 20 | 3 | B | 3.60 | 2.50 | 3.00 | 1.00 | 2.00 | 1.50 | 3.60 | 3.00 |
| 26 | 3 | B | 2.00 | 2.83 | 2.40 | 4.00 | 2.20 | 3.75 | 2.60 | 2.17 |
| 35 | 3 | B | 4.60 | 2.00 | 3.20 | 1.33 | 1.60 | 1.50 | 4.00 | 3.83 |
| 41 | 3 | B | 1.00 | 1.50 | 1.00 | 4.00 | 3.40 | 4.50 | 1.00 | 2.17 |
| 45 | 3 | B | 5.00 | 3.00 | 4.00 | 1.00 | 1.00 | 1.50 | 4.60 | 3.83 |
| 54 | 3 | B | 3.20 | 2.00 | 3.40 | 3.00 | 4.40 | 2.50 | 4.00 | 3.83 |

Table 20: Questionnaire results of participant group 5 (N = 9)

| Participant ID | Trial | Condition | Competence | Immersion | Flow | Tension | Challenge | Negative Affect | Positive Affect | Replayability |
|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 1 | B | 1.20 | 3.00 | 3.20 | 2.33 | 3.20 | 1.00 | 3.40 | 3.83 |
| 13 | 1 | B | 3.80 | 2.33 | 3.60 | 1.67 | 1.60 | 2.25 | 3.60 | 3.33 |
| 21 | 1 | B | 2.40 | 4.00 | 4.20 | 3.67 | 3.20 | 1.50 | 4.40 | 4.67 |
| 27 | 1 | B | 1.20 | 1.33 | 3.00 | 2.33 | 2.80 | 1.00 | 2.60 | 4.17 |
| 30 | 1 | B | 3.60 | 2.33 | 2.40 | 4.00 | 1.20 | 1.50 | 3.60 | 3.67 |
| 37 | 1 | B | 3.00 | 1.83 | 2.00 | 1.00 | 2.20 | 1.00 | 4.00 | 3.33 |
| 42 | 1 | B | 4.40 | 2.50 | 2.80 | 1.67 | 2.60 | 2.25 | 4.00 | 3.33 |
| 46 | 1 | B | 1.00 | 2.33 | 5.00 | 4.33 | 3.60 | 2.00 | 1.40 | 3.17 |
| 48 | 1 | B | 4.40 | 1.67 | 1.20 | 2.33 | 1.20 | 1.50 | 2.80 | 2.33 |
| 4 | 2 | A | 4.40 | 1.50 | 1.40 | 1.00 | 1.00 | 3.25 | 2.20 | 2.00 |
| 13 | 2 | A | 5.00 | 2.50 | 2.00 | 2.67 | 1.00 | 3.50 | 2.60 | 1.83 |
| 21 | 2 | A | 2.00 | 3.17 | 5.00 | 4.67 | 3.40 | 2.50 | 4.60 | 3.83 |
| 27 | 2 | A | 2.60 | 1.33 | 2.20 | 1.00 | 1.00 | 1.25 | 3.60 | 3.67 |
| 30 | 2 | A | 2.60 | 1.17 | 1.20 | 2.00 | 1.00 | 2.25 | 1.60 | 2.33 |
| 37 | 2 | A | 4.40 | 2.00 | 1.40 | 1.00 | 1.40 | 1.25 | 3.20 | 2.83 |
| 42 | 2 | A | 4.00 | 1.83 | 1.80 | 1.00 | 1.00 | 1.50 | 3.00 | 2.67 |
| 46 | 2 | A | 3.20 | 1.83 | 3.40 | 1.00 | 2.00 | 1.75 | 3.80 | 3.50 |
| 48 | 2 | A | 4.60 | 1.17 | 1.20 | 1.00 | 1.00 | 3.25 | 2.00 | 1.50 |
| 4 | 3 | C | 2.60 | 4.17 | 2.80 | 2.00 | 3.20 | 1.50 | 3.60 | 4.17 |
| 13 | 3 | C | 3.40 | 4.50 | 4.40 | 2.67 | 4.00 | 1.50 | 3.40 | 4.67 |
| 21 | 3 | C | 1.00 | 3.50 | 5.00 | 4.67 | 3.80 | 2.25 | 3.40 | 3.83 |
| 27 | 3 | C | 1.60 | 1.33 | 2.00 | 2.00 | 2.80 | 1.75 | 3.40 | 3.17 |
| 30 | 3 | C | 4.20 | 3.17 | 2.20 | 1.67 | 1.40 | 1.00 | 4.00 | 4.50 |
| 37 | 3 | C | 4.00 | 2.33 | 1.80 | 1.00 | 1.80 | 1.00 | 4.40 | 3.83 |
| 42 | 3 | C | 3.00 | 2.50 | 3.00 | 2.00 | 3.60 | 1.75 | 4.00 | 3.67 |
| 46 | 3 | C | 2.60 | 2.67 | 4.40 | 3.00 | 3.40 | 1.50 | 3.00 | 3.83 |
| 48 | 3 | C | 5.00 | 2.33 | 1.60 | 1.00 | 1.00 | 1.25 | 3.60 | 4.00 |

Table 21: Questionnaire results of participant group 6 (N = 9)

## Appendix G: Open comments

### Condition A

| PID | Group | Trial | Comment |
|---|---|---|---|
| 9 | 1 | 3 | This time I noticed that with condition A that it was a repetition of the same obstacle over and over again. |
| 18 | 1 | 3 | There were only spikes, so i could just hold down run and jump. I only used the attack button to hit the armor and grass |
| 36 | 1 | 3 | I liked this level, but that's probably because I'm bad |
| 49 | 1 | 3 | 9 was not available in the settings. I did not die :) but it felt too easy and repetitive |
| 53 | 1 | 3 | It felt very repetitive with nothing actually happening. No ennemies. It was chill but kind of boring |
| 6 | 2 | 3 | not at all |
| 10 | 2 | 3 | After the buildup of the previous two levels, this level feels completely out of place and boring, as there were no enemies and little challenge. |
| 14 | 2 | 3 | Difficulty falls once you stop engaging the enemies, and since most enemies don't have tools to stop you, it is easy to run past. |
| 15 | 2 | 3 | boring |
| 25 | 2 | 3 | once again frame buffering issues |
| 29 | 2 | 3 | This gameplay was much more repetitive than the other 2 trials. It was almost the same jump over and over. |
| 17 | 3 | 1 | repetitive platforming challenge |
| 23 | 3 | 1 | I got stuck on the ceiling in the first 5 seconds during the tutorial, and the playing around section had terrible level design |
| 19 | 4 | 1 | It were only normal long jumps, and it felt really repetitive, at some point I wondered what the goal was for it. |
| 3 | 5 | 2 | completed it at the first attempt without lives lost |
| 16 | 5 | 2 | kinda cool ngl |
| 26 | 5 | 2 | I was waiting for the puppets to be real monsters and the destroying was fun but it would be more fun if there were coins or stufs to collect from it |
| 35 | 5 | 2 | this was better |
| 13 | 6 | 2 | Thorn bush goes prick to quick |
| 30 | 6 | 2 | died once |
| 48 | 6 | 2 | 9 was not available(in the settings). I also died twice :( |

Table 22: The remarks that were made in the open comment section of the questionnaire for Condition A

### Condition B

| PID | Group | Trial | Comment |
|---|---|---|---|
| 9 | 1 | 2 | The branching and more exploratory map had more fun puzzles, but made it less clear for me what the goal was. |
| 18 | 1 | 2 | I died twice |
| 22 | 1 | 2 | The hitbox of the thorns is bigger than it seems, which isn't fun |
| 28 | 1 | 2 | Finished with 15 lives again. Saw some pieces of the level that were the same as in the previous trial (randomly generated with seeds etc? - cool). Even though I finished one route that led to the end, I was slight confused as to what the correct route was / where the other routes would go. |
| 39 | 1 | 2 | Lives didn't seem to go down even when I got hit. The map layout was a bit confusing and some parts looked the same so I wasn't sure where to go. |
| 49 | 1 | 2 | Died twice. |
| 6 | 2 | 1 | no, nothing |
| 14 | 2 | 1 | Too simple a jump test, some variation may enhance |
| 15 | 2 | 1 | I died twice. Especially the gap between the thorns near the spawn is hard. |
| 25 | 2 | 1 | the vine hitbox doesnt really feel nice |
| 29 | 2 | 1 | (about quesitonaire): some questions are almost identical. e.g. I found it tiresome/ I got tired of playing this game. (about game): finished the level with all my 15 lives :) |
| 50 | 2 | 1 | I did twice, I could not get through the vines on both sides section, were you had to jump. I also noticed that sometimes the character resets to like a checkpoint(?) after losing two lives in a row, not sure if it is a bug or a feature. |
| 5 | 3 | 2 | all good |
| 11 | 3 | 2 | I died twice in this trial |
| 17 | 3 | 2 | I only had to jump. At first I died a few times because I had gotten used to tapping the jump button. but when I started holding it a lot of the jumps were the exact arc that I needed |
| 23 | 3 | 2 | directions were unclear/misinformative |
| 19 | 4 | 3 | I died twice but did it a third time and then I got to the goal |
| 34 | 4 | 3 | In stage B, the vines on one of the first platforms went slightly above the platform, which was a little annoying. Didn't ruin the experience, just made me feel a little cheated as a player. I enjoyed the linear, platforming, and "timing based," design a lot. |
| 3 | 5 | 3 | died twice, plant thingies kept killing me :( |
| 26 | 5 | 3 | i died , i strugled a lot with the long jump mechanic of keep holding space |
| 41 | 5 | 3 | I died twice |
| 4 | 6 | 1 | I died twice in trial 1 |
| 13 | 6 | 1 | De blokken waar je op springt vallen een beetje weg in de achtergrond en zijn dus slecht zichtbaar |
| 27 | 6 | 1 | I died twice (at the same point) then had to press esc |
| 30 | 6 | 1 | my main irritation in this trial was that the vines have a pretty big hitbox so jumps where much more precise than they looked. |
| 37 | 6 | 1 | I am going to make a wild guess and say this was the platforming/trap avoidance trial. As far as that goes the game plays well. Only thing is that it's bit tricky to tell how long a jump will be since it feels like you get more vertical disntance when you also jump horizontally, which is bit odd (yes I did press down space). But I am also qite bad a platformers so I will not call it a flaw with the game, might very well be a skill issue on my part. What might be a bug though, when you are mid air and you take damage from the environment (spikes, thorns, ...) you get reset back to your last bit of solid ground. I think that it's an intended mechanic, but the camera tends to freak out when it happes and it doesn't trigger consistently, so I am geuenly unsure. |
| 42 | 6 | 1 | Some framedrops, but only once or twice |
| 46 | 6 | 1 | Died in the first level |
| 48 | 6 | 1 | Jumping momentum feels.. strange? It might be that I am used to the exact Hollow Knight movement (which this game is clearly inspired by) but jumping didn't feel exactly right. |

Table 23: The remarks that were made in the open comment section of the questionnaire for Condition B

**Condition C**

| PID | Group | Trial | Comment |
|---|---|---|---|
| 9 | 1 | 1 | The shuriken's of the ninja's would sometimes get stuck in the wall or floor in small area's making it almost impossible to go through unless you waited for it to dissappear |
| 18 | 1 | 1 | The character is really cute. Sometimes the teleporter guys would kill themselves by teleporting into the thorn bushes |
| 28 | 1 | 1 | Should the side of a fading block be resetting the jump? I felt like this was only the case sometimes. But I could have wrongly observed this. |
| 32 | 1 | 1 | I died twice in the same level |
| 36 | 1 | 1 | I fkn died twice at that crumbeling rock bit where you have to climb up wall jump doesn't work on those crumbly bits |
| 39 | 1 | 1 | i died at the part where you have to jump up to the one blocks that dissapear, I died once. |
| 49 | 1 | 1 | I died twice :( |
| 6 | 2 | 2 | The shinobi enemy does not teleport/ start attacking if u float above it, and u can hit the shield guy through the shield (idk if that is supposed to be possible but it took 3 hits to kill the shields while standing in front of them) |
| 14 | 2 | 2 | I died twice |
| 1 | 3 | 3 | I died once during this trial, it was more challenging which i enjoyed |
| 5 | 3 | 3 | The part where you zigzag up between spikes and falling blocks was the hardest part, as i feel that the spike boundingboxes could use some work. Overall, great experience |
| 17 | 3 | 3 | nah |
| 33 | 3 | 3 | I died one time at the single crumbling blocks where you have to move up. |
| 38 | 3 | 3 | It would be nice if there were some actual things to find apart from extra lives |
| 43 | 3 | 3 | Could not finish the level after many tries and was annoyed :) |
| 12 | 4 | 2 | Geen hartje verloren |
| 24 | 4 | 2 | had a lot of weird frame buffering issues which made some jumps almost impossible |
| 3 | 5 | 1 | died twice |
| 16 | 5 | 1 | Toen min 15 levens opwaren kon ik wel weer opnieuw starten, en had niet het idee dat ik al een level verder was, maar eigenlijk weet ik het ook niet zeker |
| 20 | 5 | 1 | I died twice on the same part. Where you have to jump on crumbling blocks with vines all around you. Kinda felt like the hitbox of the vine was larger than the texture so felt a little unfair when I was hit when it did not touch me on screen |
| 26 | 5 | 1 | i died, i strugled a lot with the long jump mechanic of keep holding space |
| 41 | 5 | 1 | I died twice |
| 54 | 5 | 1 | The background is too dark , colorful games are more interesting for me |
| 13 | 6 | 3 | Omdat ik niet zo goed wist waar ik heen ging en er zo veel wegen/mogelijkheden waren werd ik juist benieuwd naar wat er nog ging komen. + Ik voelde mij gedurende het spel (omdat het wat moeilijker was) wat minder competent. Echter naarmate ik dichter bij het eind kwam en zeker toen ik het einde haalde voelde ik me juist weer een stuk bekwamer. Dit gaf mij smaak om verder te spelen en nog meer uitgedaagd te worden. |
| 27 | 6 | 3 | Died twice on the part where you needed to hit the blocks above you and get up |
| 30 | 6 | 3 | got stuck at in some goop with vines around it and could not jump high enough. |
| 37 | 6 | 3 | A well put togheter level with a good pace. I like the sadistic placement of heals. Also I think this was mentioned to you in person, but the shield guys deperaely need a couter to just jumping on their head. |
| 46 | 6 | 3 | Died on the first level again |
| 48 | 6 | 3 | This trial, in contrast to the other 2, actually felt quite good to play. It was somewhat succesful at replicating Hollow Knight's sprawling caves and it had quite a variety of things to do. The main thing that I noticed was that because this level was way more open, it felt better to play. Jumping in small amounts feels kinda bad, and having to fight for example the shieldbearer enemies with a low ceiling is designed kinda unfairly. In its current state, the game benefits from big rooms. |

Table 24: The remarks that were made in the open comment section of the questionnaire for Condition C

# References


[1] Espen Aarseth. Allegories of space. *Space Time Play*, 20, 2007.

[2] Paul JC Adachi and Teena Willoughby. More than just fun and games: the longitudinal relationships between strategic video games, self-reported problem solving skills, and academic grades. *Journal of youth and adolescence*, 42(7):1041–1052, 2013.

[3] Anne Adams and Anna L Cox. *Questionnaires, in-depth interviews and focus groups.* Cambridge University Press, 2008.

[4] Wilfried Admiraal, Jantina Huizenga, Sanne Akkerman, and Geert Ten Dam. The concept of flow in collaborative game-based learning. *Computers in human behavior*, 27(3):1185–1194, 2011.

[5] Courtney Aison, Gideon Davis, Jennifer Milner, and Elliot Targum. Appeal and interest of video game use among the elderly. *Harvard Graduate School of Education*, 2002.

[6] Abdullah Al Mahmud, Omar Mubin, Suleman Shahid, and Jean-Bernard Martens. Designing social games for children and older adults: Two related case studies. *Entertainment Computing*, 1(3-4):147–156, 2010.

[7] Clark Aldrich. *Simulations and the future of learning: An innovative (and perhaps revolutionary) approach to e-learning.* John Wiley & Sons, 2003.

[8] Clark Aldrich. Virtual worlds, simulations, and games for education: A unifying view. *Innovate: Journal of Online Education*, 5(5), 2009.

[9] Justin T Alexander, John Sear, and Andreas Oikonomou. An investigation of the effects of game difficulty on player enjoyment. *Entertainment computing*, 4(1):53–62, 2013.

[10] Leonard A Annetta, James Minogue, Shawn Y Holmes, and Meng-Tzu Cheng. Investigating the impact of video games on high school students' engagement and learning about genetics. *Computers & Education*, 53(1):74–85, 2009.

[11] Matthew T Atkinson, Sabahattin Gucukoglu, Colin HC Machin, and Adrian E Lawrence. Making the mainstream accessible: redefining the game. In *Proceedings of the 2006 ACM SIGGRAPH Symposium on Videogames*, pages 21–28, 2006.

[12] Matthew T Atkinson, Sabahattin Gucukoglu, Colin HC Machin, and Adrian E Lawrence. Making the mainstream accessible: What's in a game? In *International Conference on Computers for Handicapped Persons*, pages 380–387. Springer, 2006.

[13] Ruth Aylett. Emergent narrative, social immersion and "storification". In *Proceedings of the 1st international workshop on narrative and interactive learning environments*, pages 35–44, 2000.

[14] Christine M Bachen and Chad Raphael. Social flow and learning in digital games: A conceptual model and research agenda. *Serious games and edutainment applications*, pages 61–84, 2011.

[15] Stacy A Balk, Dakota B Bertola, and Vaughan W Inman. Simulator sickness questionnaire: twenty years later. In *Driving Assesment Conference*, volume 7. University of Iowa, 2013.

[16] Albert Bandura. Self-efficacy: toward a unifying theory of behavioral change. *Psychological review*, 84(2):191, 1977.

[17] Tom Baranowski, Richard Buday, Debbe I Thompson, and Janice Baranowski. Playing for real: video games and stories for health-related behavior change. *American journal of preventive medicine*, 34(1):74–82, 2008.

[18] Scott Bateman, Regan L Mandryk, Tadeusz Stach, and Carl Gutwin. Target assistance for subtly balancing competitive play. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 2355–2364, 2011.

[19] Geertje Bekebrede, HJG Warmelink, and IS Mayer. Reviewing the need for gaming in education to accommodate the net generation. *Computers & Education*, 57(2):1521–1529, 2011.

[20] Francesco Bellotti, Riccardo Berta, and Alessandro De Gloria. Designing effective serious games: opportunities and challenges for research. *International Journal of Emerging Technologies in Learning (iJET)*, 5(2010), 2010.

[21] Gerard R Bentley and Joseph C Osborn. The videogame affordances corpus. In *2019 Experimental AI in Games Workshop*, 2019.

[22] Carl Bereiter and Marlene Scardamalia. Surpassing ourselves. *An inquiry into the nature and implications of expertise. Chicago: Open Court*, 1993.

[23] Arthur Asa Berger. *Video games: A popular culture phenomenon*. Routledge, 2017.

[24] Sara Bernardini, Kaśka Porayska-Pomsta, and Tim J Smith. Echoes: An intelligent serious game for fostering social communication in children with autism. *Information Sciences*, 264:41–60, 2014.

[25] Regina Bernhaupt, Manfred Eckschlager, and Manfred Tscheligi. Methods for evaluating games: how to measure usability and user experience in games? In *Proceedings of the international conference on Advances in computer entertainment technology*, pages 309–310, 2007.

[26] Nadia Bianchi-Berthouze, Whan Woong Kim, and Darshak Patel. Does body movement engage you more in digital game play? and why? In *International conference on affective computing and intelligent interaction*, pages 102–113. Springer, 2007.

[27] Kevin Bierre, Jonathan Chetwynd, Barrie Ellis, D Michelle Hinn, Stephanie Ludi, and Thomas Westin. Game not over: Accessibility issues in video games. In *Proc. of the 3rd International Conference on Universal Access in Human-Computer Interaction*, pages 22–27, 2005.

[28] Kevin Bierre, Michelle Hinn, Teresa Martin, Michael McIntosh, Tess Snider, Katie Stone, and Thomas Westin. Accessibility in games: Motivations and approaches. *White paper, International Game Developers Association (IGDA)*, 2004.

[29] Staffan Björk, Sus Lundgren, and Jussi Holopainen. Game design patterns. In *Game Design Patterns*. Citeseer, 01 2003.

[30] Lisa S Blackwell, Kali H Trzesniewski, and Carol Sorich Dweck. Implicit theories of intelligence predict achievement across an adolescent transition: A longitudinal study and an intervention. *Child development*, 78(1):246–263, 2007.

[31] Johan Blomberg. The semiotics of the game controller. *Game Studies*, 18(2):3, 2018.

[32] Johannes Breuer and Gary Bente. Why so serious? on the relation of serious games and learning. *Journal for Computer Game Culture*, 4:7–24, 2010.

[33] Nathan Brewer. Computerized dungeons and randomly generated worlds: From rogue to minecraft [scanning our past]. *Proceedings of the IEEE*, 105(5):970–977, 2017.

[34] Jeanne H Brockmyer, Christine M Fox, Kathleen A Curtiss, Evan McBroom, Kimberly M Burkhart, and Jacquelyn N Pidruzny. The development of the game engagement questionnaire: A measure of engagement in video game-playing. *Journal of experimental social psychology*, 45(4):624–634, 2009.

[35] Emily Brown and Paul Cairns. A grounded investigation of game immersion. In *CHI'04 extended abstracts on Human factors in computing systems*, pages 1297–1300, 2004.

[36] Stephanie J Brown, Debra A Lieberman, BA Gemeny, Yong Chan Fan, DM Wilson, and DJ Pasta. Educational video game for juvenile diabetes: results of a controlled trial. *Medical informatics*, 22(1):77–89, 1997.

[37] Grigore C Burdea. Virtual rehabilitation–benefits and challenges. *Methods of information in medicine*, 42(05):519–523, 2003.

[38] James William Burke, MDJ McNeill, Darryl K Charles, Philip J Morrow, Jacqui H Crosbie, and Suzanne M McDonough. Optimising engagement for stroke rehabilitation using serious games. *The Visual Computer*, 25(12):1085–1099, 2009.

[39] Clark C. Abt, clark c. serious games. new york: Viking, 1970, 176 pp. *American Behavioral Scientist*, 14(1):129–129, 1975.

[40] Roger Caillois. The definition of play. *The Game Design Reader: A Rules of Play Anthology*, pages 123–28, 1961.

[41] Ben Caldwell, Michael Cooper, Loretta Guarino Reid, Gregg Vanderheiden, Wendy Chisholm, John Slatin, and Jason White. Web content accessibility guidelines (wcag) 2.0. *WWW Consortium (W3C)*, 290:1–34, 2008.

[42] Mónica S Cameirao, Sergi Bermúdez i Badia, Esther Duarte Oller, and Paul FMJ Verschure. The rehabilitation gaming system: a review. *Advanced Technologies in Rehabilitation*, pages 65–83, 2009.

[43] Anna Cavender, Shari Trewin, and Vicki Hanson. General writing guidelines for technology and people with disabilities. *ACM SIGACCESS Accessibility and Computing*, (92):17–22, 09 2008.

[44] Jared E Cechanowicz, Carl Gutwin, Scott Bateman, Regan Mandryk, and Ian Stavness. Improving player balancing in racing games. In *Proceedings of the first ACM SIGCHI annual symposium on Computer-human interaction in play*, pages 47–56, 2014.

[45] Therese Charles, David Bustard, and Michaela Black. Experiences of promoting student engagement through game-enhanced learning. In *Serious games and edutainment applications*, pages 425–445. Springer, 2011.

[46] Nathalie Charlier, Michela Ott, Bernd Remmele, and Nicola Whitton. Not just for children: game-based learning for older adults. In *6th European Conference on Games Based Learning, Cork, Ireland*, pages 102–108, 2012.

[47] Dennis Charsky and Clif Mims. Integrating commercial off-the-shelf video games into school curriculums. *TechTrends*, 52(5):38–44, 2008.

[48] Jenova Chen. Flow in games (and everything else). *Communications of the ACM*, 50(4):31–34, 2007.

[49] Mark Chen, Beth E Kolko, Elisabeth Cuddihy, and Eliana Medina. Modeling but not measuring engagement in computer games. In *Proceedings of the 7th international conference on Games+ Learning+ Society Conference*, pages 55–63, 2011.

[50] D Clark. Computer games in education and training. In *Presentation at LSDA seminar Learning by playing: can computer games and simulations support teaching and learning for post-16 learners in formal, workplace and informal learning contexts*, volume 20, 2003.

[51] A. Conconi, T. Ganchev, O. Kocsis, G. Papadopoulos, F. Fernandez-Aranda, and S. Jimenez-Murcia. Playmancer: A serious gaming 3d environment. In *Proceedings of the 4th International Conference on Automated Solutions for Cross Media Content and Multi-Channel Distribution*. AXMEDIS, Nov. 17-19, 2008.

[52] Anna Cox, Paul Cairns, Pari Shah, and Michael Carroll. Not doing but thinking: the role of challenge in the gaming experience. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 79–88, 2012.

[53] Chris Crawford. *Chris Crawford on game design*. New Riders, 2003.

[54] Kevin L Crow. Four types of disabilities: Their impact on online learning. *TechTrends*, 52(1):51–55, 2008.

[55] Mihaly Csikszentmihalyi. *Das flow-Erlebnis: jenseits von Angst und Langeweile: im Tun aufgehen (The Flow Experience; beyond fear and boredom: opening in doing)*. Klett-Cotta, 10 edition, 1985/1975.

[56] Mihaly Csikszentmihalyi. The flow experience and its significance for human psychology. *Optimal experience: Psychological studies of flow in consciousness*, 2:15–35, 1988.

[57] Mihaly Csikszentmihalyi. *Flow: The psychology of optimal experience*, volume 1990. Harper & Row New York, 1990.

[58] J Dattilo, DA Kleiber, et al. Psychological perspectives for therapeutic recreation research: the psychology of enjoyment. *Research in therapeutic recreation: concepts and methods.*, pages 57–76, 1993.

[59] Sara De Freitas and Martin Oliver. How can exploratory learning with games and simulations within the curriculum be most effectively evaluated? *Computers & education*, 46(3):249–264, 2006.

[60] Yvonne AW De Kort, Wijnand A IJsselsteijn, and Karolien Poels. Digital games as social presence technology: Development of the social presence in gaming questionnaire (spgq). *Proceedings of PRESENCE*, 195203:1–9, 2007.

[61] Aijse W de Vries, Gert Faber, Ilse Jonkers, Jaap H Van Dieen, and Sabine MP Verschueren. Virtual reality balance training for elderly: Similar skiing games elicit different challenges in balance training. *Gait & posture*, 59:111–116, 2018.

[62] Edward L Deci, Robert J Vallerand, Luc G Pelletier, and Richard M Ryan. Motivation and education: The self-determination perspective. *Educational psychologist*, 26(3-4):325–346, 1991.

[63] Alena Denisova and Paul Cairns. First person vs. third person perspective in digital games: do player preferences affect immersion? In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, pages 145–148, 2015.

[64] Sha Ding, Ningjiu Tang, Tao Lin, and Shiyuan Zhao. Rts-gameflow: a new evaluation framework for rts games. In *2009 International Conference on Computational Intelligence and Software Engineering*, pages 1–4. IEEE, 2009.

[65] Lars Doucet and Vinod Srinivasan. Designing entertaining educational games using procedural rhetoric: a case study. In *Proceedings of the 5th ACM SIGGRAPH Symposium on Video Games*, pages 5–10, 2010.

[66] Sharon Dugdale and David Kibbey. Fractions curriculum of the plato elementary school mathematics project. 1980.

[67] Kevin Durkin. Game playing and adolescents' development. 2006.

[68] Kevin Durkin and Kate Aisbett. *Computer games and Australians today*. Office of Film and Literature Classification, 1999.

[69] Robert F Dyer et al. Questionnaire construction manual annex: Literature survey and bibliography. 1976.

[70] S Engl. mobile gaming–eine empirische studie zum spielverhalten und nutzungserlebnis in mobilen kontexten. *Magister thesis, Universität Regensburg*, 2010.

[71] Nielsen Interactive Entertainment. Video gamers in europe–2005. *Prepared for the Interactive Software Federation of Europe*, 2005.

[72] K Anders Ericsson and Reid Hastie. Contemporary approaches to the study of thinking and problem solving. In *Thinking and problem solving*, pages 37–79. Elsevier, 1994.

[73] David R Ewoldsen, Cassie A Eno, Bradley M Okdie, John A Velez, Rosanna E Guadagno, and Jamie DeCoster. Effect of playing violent video games cooperatively or competitively on subsequent cooperative behavior. *Cyberpsychology, Behavior, and Social Networking*, 15(5):277–280, 2012.

[74] Carlo Fabricatore. *Playability in action videogames: a theoretical design reference*. PhD thesis, Ph. D. Catholic University of Chile, 1999.

[75] Carlo Fabricatore. Gameplay and game mechanics: a key to quality in videogames. 2007.

[76] Carlo Fabricatore, Miguel Nussbaum, and Ricardo Rosas. Playability in action videogames: A qualitative design model. *Human-Computer Interaction*, 17(4):311–368, 2002.

[77] Juan Fasola and Maja J Mataric. Robot exercise instructor: A socially assistive robot system to monitor and encourage physical exercise for the elderly. In *19th International Symposium in Robot and Human Interactive Communication*, pages 416–421. IEEE, 2010.

[78] B.O. Fernandes. Exploring possibilities in interactive technology to create cross-domain interactive breathing exercise games. `http://essay.utwente.nl/85593/`, January 2021.

[79] Andy Field. *Discovering statistics using IBM SPSS statistics.* sage, 2013.

[80] Bernadette Flynn. Games as inhabited spaces. *Media International Australia*, 110(1):52–61, 2004.

[81] Eelke Folmer. Usability patterns in games. *Future Play*, 6:21, 2006.

[82] Fong-Ling Fu, Rong-Chang Su, and Sheng-Chin Yu. Egameflow: A scale to measure learners' enjoyment of e-learning games. *Computers & Education*, 52(1):101–112, 2009.

[83] B Galego and L Simone. Leveraging online virtual worlds for upper extremity rehabilitation. In *2007 IEEE 33rd Annual Northeast Bioengineering Conference*, pages 267–268. IEEE, 2007.

[84] PopCap Games. Survey: 'disabled gamers' comprise 20% of casual video games audience, 2008.

[85] Eduardo H Calvillo Gámez, Paul Cairns, and Anna L Cox. From the gaming experience to the wider user experience. *People and Computers XXIII Celebrating People and Technology*, pages 520–523, 2009.

[86] Rosemary Garris, Robert Ahlers, and James E Driskell. Games, motivation, and learning: A research and practice model. In *Simulation in Aviation Training*, pages 475–501. Routledge, 2017.

[87] James Paul Gee. What video games have to teach us about learning and literacy. *Computers in entertainment (CIE)*, 1(1):20–20, 2003.

[88] James Paul Gee. Good video games and good learning (new literacies and digital epistemologies). *New York, NY: Peter Lang Publishing, Inc*, 10:978–1, 2007.

[89] Douglas A Gentile, Craig A Anderson, Shintaro Yukawa, Nobuko Ihori, Muniba Saleem, Lim Kam Ming, Akiko Shibuya, Albert K Liau, Angeline Khoo, Brad J Bushman, et al. The effects of prosocial video games on prosocial behaviors: International evidence from correlational, longitudinal, and experimental studies. *Personality and Social Psychology Bulletin*, 35(6):752–763, 2009.

[90] Kathrin M Gerling, Matthias Klauser, and Joerg Niesenhaus. Measuring the impact of game controllers on player experience in fps games. In *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments*, pages 83–86, 2011.

[91] Kathrin M Gerling, Frank P Schulte, and Maic Masuch. Designing and evaluating digital games for frail elderly persons. In *Proceedings of the 8th international conference on advances in computer entertainment technology*, pages 1–8, 2011.

[92] Kiel M Gilleade and Alan Dix. Using frustration in the design of adaptive videogames. In *Proceedings of the 2004 ACM SIGCHI International Conference on Advances in computer entertainment technology*, pages 228–232, 2004.

[93] Coralie Girard, Jean Ecalle, and Annie Magnan. Serious games as new educational tools: how effective are they? a meta-analysis of recent studies. *Journal of computer assisted learning*, 29(3):207–219, 2013.

[94] Dion H Goh, Rebecca P Ang, and Hui Chern Tan. Strategies for designing effective psychotherapeutic gaming interventions for children and adolescents. *Computers in Human Behavior*, 24(5):2217–2235, 2008.

[95] Arthur Graesser, P Chipman, F Leeming, and S Biedenbach. Serious games: mechanisms and effects, 2009.

[96] Dimitris Grammenos. Game over: learning by dying. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 1443–1452, 2008.

[97] Dimitris Grammenos, Anthony Savidis, Yannis Georgalis, and Constantine Stephanidis. Access invaders: Developing a universally accessible action game. In *International conference on computers for handicapped persons*, pages 388–395. Springer, 2006.

[98] Dimitris Grammenos, Anthony Savidis, and Constantine Stephanidis. Ua-chess: A universally accessible board game. In *Proceedings of the 3rd International Conference on Universal Access in Human-Computer Interaction, Las Vegas, Nevada (July 2005)*, 2005.

[99] Isabela Granic, Adam Lobel, and Rutger CME Engels. The benefits of playing video games. *American psychologist*, 69(1):66, 2014.

[100] Margaret E Gredler. Games and simulations and their relationships to learning. In *Handbook of research on educational communications and technology*, pages 571–581. Routledge, 2013.

[101] C Shawn Green and Daphne Bavelier. Learning, attentional control, and action video games. *Current biology*, 22(6):R197–R206, 2012.

[102] Eric A Greenleaf. Improving rating scale measures by detecting and correcting bias components in some response styles. *Journal of Marketing Research*, 29(2):176–188, 1992.

[103] James J Gross and Oliver P John. Individual differences in two emotion regulation processes: implications for affect, relationships, and well-being. *Journal of personality and social psychology*, 85(2):348, 2003.

[104] WS Lal Gunasekera and June Bendall. Rehabilitation of neurologically injured patients. In *Neurosurgery*, pages 407–421. Springer, 2005.

[105] Thomas Hainey, Thomas M Connolly, Mark Stansfield, and Elizabeth A Boyle. Evaluation of a game to teach requirements collection and analysis in software engineering at tertiary education level. *Computers & Education*, 56(1):21–35, 2011.

[106] Juho Hamari, David J Shernoff, Elizabeth Rowe, Brianno Coller, Jodi Asbell-Clarke, and Teon Edwards. Challenging games help students learn: An empirical study on engagement, flow and immersion in game-based learning. *Computers in human behavior*, 54:170–179, 2016.

[107] Marc Hassenzahl. User experience (ux) towards an experiential perspective on product quality. In *Proceedings of the 20th Conference on l'Interaction Homme-Machine*, pages 11–15, 2008.

[108] Scott Henninger. A methodology and tools for applying context-specific usability guidelines to interface design. *Interacting with computers*, 12(3):225–243, 2000.

[109] MA Hersh and B Leporini. Accessibility and usability of educational games for disabled students. *Student usability in educational software and games: improving experiences*, pages 1–40, 2012.

[110] Alexander Hofmann and Helmut Hlavacs. Gaming and entertainment technologies for includification. In *2015 3rd IEEE VR International Workshop on Virtual and Augmented Assistive Technology (VAAT)*, pages 5–7. IEEE, 2015.

[111] Maureen K Holden. Virtual environments for motor rehabilitation. *Cyberpsychology & behavior*, 8(3):187–211, 2005.

[112] Yan Huang, Stefanus Jasin, and Puneet Manchanda. "level up": Leveraging skill and engagement to maximize player game-play in online video games. *Information Systems Research*, 30(3):927–947, 2019.

[113] Johan Huizinga. Nature and significance of play as a cultural phenomenon. *Huizinga, J.: Homo Ludens–A Study of the Play-Element in Culture, Boston (Beacon Press) 1955, pp. 1-27.*, 1955.

[114] IGDA-SIG. Igda-sig: International game developers association (igda) game accessibility special interest group (sig). [online]. `https://igda.org/sigs-directory/`, 2007. Accessed: 08-12-2021.

[115] Kiran Ijaz, Naseem Ahmadpour, Yifan Wang, and Rafael A Calvo. Player experience of needs satisfaction (pens) in an immersive virtual reality exercise platform describes motivation and enjoyment. *International Journal of Human–Computer Interaction*, 36(13):1195–1204, 2020.

[116] Wijnand A IJsselsteijn, Yvonne AW De Kort, and Karolien Poels. The game experience questionnaire. 2013.

[117] Nina Iten and Dominik Petko. Learning with serious games: Is fun playing the game a predictor of learning success? *British Journal of Educational Technology*, 47(1):151–163, 2016.

[118] Linda A Jackson, Edward A Witt, Alexander Ivan Games, Hiram E Fitzgerald, Alexander Von Eye, and Yong Zhao. Information technology use and creativity: Findings from the children and technology project. *Computers in human behavior*, 28(2):370–376, 2012.

[119] Daniela Janßen, Christian Tummel, Anja Richert, and Ingrid Isenhardt. Towards measuring user experience, activation and task performance in immersive virtual learning environments for students. In *International conference on immersive learning*, pages 45–58. Springer, 2016.

[120] Aki Järvinen, Satu Heliö, and Frans Mäyrä. *Communication and community in digital entertainment services. Prestudy Research Report. Hypermedia Laboratory Net Series 2, University of Tampere*. 2002.

[121] Kalle Jegers. Pervasive game flow: understanding player enjoyment in pervasive gaming. *Computers in Entertainment (CIE)*, 5(1):9–es, 2007.

[122] Kalle Jegers. Elaborating eight elements of fun: Supporting design of pervasive player enjoyment. *Computers in Entertainment (CIE)*, 7(2):1–22, 2009.

[123] Henry Jenkins. Game design as narrative architecture. *Computer*, 44(3):118–130, 2004.

[124] Charlene Jennett, Anna L Cox, Paul Cairns, Samira Dhoparee, Andrew Epps, Tim Tijs, and Alison Walton. Measuring and defining the experience of immersion in games. *International journal of human-computer studies*, 66(9):641–661, 2008.

[125] Charlene Jennett, Anna L Cox, Paul Cairns, Samira Dhoparee, Andrew Epps, Tim Tijs, and Alison Walton. Measuring and defining the experience of immersion in games. *International journal of human-computer studies*, 66(9):641–661, 2008.

[126] Seung-A Annie Jin. "toward integrative models of flow": Effects of performance, skill, challenge, playfulness, and presence on flow in video games. *Journal of Broadcasting & Electronic Media*, 56(2):169–186, 2012.

[127] Daniel Johnson, M John Gardner, and Ryan Perry. Validation of two game experience scales: the player experience of need satisfaction (pens) and game experience questionnaire (geq). *International Journal of Human-Computer Studies*, 118:38–46, 2018.

[128] Daniel Johnson, Lennart E Nacke, and Peta Wyeth. All about that base: differing player experiences in video game genres and the unique case of moba games. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, pages 2265–2274, 2015.

[129] W. Lewis Johnson, Hannes Högni Vilhjálmsson, and Stacy Marsella. Serious games for language learning: How much game, how much ai? In *AIED*, volume 125, pages 306–313, 2005.

[130] Kari Kallinen, Mikko Salminen, Niklas Ravaja, Ryszard Kedzior, and Maria Sääksjärvi. Presence and emotion in computer game players during 1st person vs. 3rd person playing view: Evidence from self-report, eye-tracking, and facial muscle activity data. *Proceedings of the PRESENCE*, 187:190, 2007.

[131] Robert S Kennedy, Norman E Lane, Kevin S Berbaum, and Michael G Lilienthal. Simulator sickness questionnaire: An enhanced method for quantifying simulator sickness. *The international journal of aviation psychology*, 3(3):203–220, 1993.

[132] Ahmed Khalifa, Michael Cerny Green, Diego Perez-Liebana, and Julian Togelius. General video game rule generation. In *2017 IEEE Conference on Computational Intelligence and Games (CIG)*, pages 170–177. IEEE, 2017.

[133] Ahmed Khalifa, Diego Perez-Liebana, Simon M Lucas, and Julian Togelius. General video game level generation. In *Proceedings of the Genetic and Evolutionary Computation Conference 2016*, pages 253–259, 2016.

[134] Eng Tat Khoo and Adrian David Cheok. Age invaders: inter-generational mixed reality family game. *International Journal of Virtual Reality*, 5(2):45–50, 2006.

[135] Kristian Kiili. Digital game-based learning: Towards an experiential gaming model. *The Internet and higher education*, 8(1):13–24, 2005.

[136] C Klimmt, AS Rizzo, P Vorderer, J Koch, and T Fischer. Suspense as dimension of video game enjoyment. In *Game Studies special interest group at the annual conference of the International Communication Association, San Francisco, CA*, 2007.

[137] Anatoly N Krichevets, EB Sirotkina, IV Yevsevicheva, and LM Zeldin. Computer games as a means of movement rehabilitation. *Disability and rehabilitation*, 17(2):100–105, 1995.

[138] Lorraine Lanningham-Foster, Teresa B Jensen, Randal C Foster, Aoife B Redmond, Brian A Walker, Dieter Heinz, and James A Levine. Energy expenditure of sedentary screen time compared with active screen time for children. *Pediatrics*, 118(6):e1831–e1835, 2006.

[139] Effie L-C Law, Florian Brühlmann, and Elisa D Mekler. Systematic review and validation of the game experience questionnaire (geq)-implications for citation and reporting practice. In *Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play*, pages 257–270, 2018.

[140] Effie Lai-Chong Law and Xu Sun. Evaluating user experience of adaptive digital educational games with activity theory. *International journal of human-computer studies*, 70(7):478–497, 2012.

[141] Nicole Lazzaro and Kevin Keeker. What's my method? a game show on games. In *CHI'04 Extended Abstracts on Human Factors in Computing Systems*, pages 1093–1094, 2004.

[142] KM Lee and W Peng. What do we know about social and psychological effects of computer games? in p. vorderer, & j. bryant (eds.) playing video games: Motives, responses, and consequences. *Hillsdale, NJ: LEA*, 2006.

[143] Mark R Lepper and David Greene. *The hidden costs of reward: New perspectives on the psychology of human motivation.* Psychology Press, 1978.

[144] Mark R Lepper and Jennifer Henderlong. Turning "play" into "work" and "work" into "play": 25 years of research on intrinsic versus extrinsic motivation. *Intrinsic and extrinsic motivation*, pages 257–307, 2000.

[145] Debra A Lieberman. Dance games and other exergames: What the research says. 2006.

[146] Debra A Lieberman. What can we learn from playing interactive games. *Playing video games: Motives, responses, and consequences*, pages 379–397, 2006.

[147] Philip Lindner, Alexander Rozental, Alice Jurell, Lena Reuterskiöld, Gerhard Andersson, William Hamilton, Alexander Miloff, and Per Carlbring. Experiences of gamified and automated virtual reality exposure therapy for spider phobia: qualitative study. *JMIR serious games*, 8(2):e17807, 2020.

[148] Derek Lomas, Kishan Patel, Jodi L Forlizzi, and Kenneth R Koedinger. Optimizing challenge in an educational game using large-scale design experiments. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 89–98, 2013.

[149] Feiyu Lu, Difeng Yu, Hai-Ning Liang, Wenjun Chen, Konstantinos Papangelis, and Nazlena Mohamad Ali. Evaluating engagement level and analytical support of interactive visualizations in virtual reality environments. In *2018 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, pages 143–152. IEEE, 2018.

[150] Minhua Ma and Kamal Bechkoum. Serious games for movement therapy after stroke. In *2008 IEEE international conference on systems, man and cybernetics*, pages 1872–1877. IEEE, 2008.

[151] I. Scott MacKenzie and Robert J. Teather. Fittstilt: The application of fitts' law to tilt-based interaction. In *Proceedings of the 7th Nordic Conference on Human-Computer Interaction: Making Sense Through Design*, NordiCHI '12, page 568–577, New York, NY, USA, 2012. Association for Computing Machinery.

[152] Thomas W Malone. What makes things fun to learn? heuristics for designing instructional computer games. In *Proceedings of the 3rd ACM SIGSMALL symposium and the first SIGPC symposium on Small systems*, pages 162–169, 1980.

[153] Thomas W Malone. Toward a theory of intrinsically motivating instruction. *Cognitive science*, 5(4):333–369, 1981.

[154] Thomas W Malone. What makes computer games fun? In *Proceedings of the Joint Conference on Easier and More Productive Use of Computer Systems.(Part-II): Human Interface and the User Interface-Volume 1981*, page 143, 1981.

[155] Thomas W Malone. What makes things fun to learn? a study of intrinsically motivating computer games. 1981.

[156] Thomas W Malone and Mark R Lepper. Making learning fun: A taxonomy of intrinsic motivations for learning. In *Aptitude, learning, and instruction*, chapter III: Conative and affective process analysis, pages 223–254. Lawrence Erlbaum Associates, 1987.

[157] J Garcia Marin, K Felix Navarro, and Elaine Lawrence. Serious games to improve the physical health of the elderly: A categorization scheme. In *International Conference on Advances in Human-oriented and Personalized Mechanisms, Technologies, and Services. Barcelona, Spain*, 2011.

[158] Tim Marsh. Serious games continuum: Between games for purpose and experiential environments for purpose. *Entertainment Computing*, 2(2):61–68, 2011.

[159] Jane McGonigal. *Reality is broken: Why games make us better and how they can change the world*. Penguin, 2011.

[160] Georgia Leigh McGregor and Baba Akira. Situations of play: Patterns of spatial use in videogames. In *DiGRA Conference*, 2007.

[161] Eliana Medina, Ruth Fruland, and Suzanne Weghorst. Virtusphere: Walking in a human size vr "hamster ball". In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, volume 52, pages 2102–2106. SAGE Publications Sage CA: Los Angeles, CA, 2008.

[162] Elisa D Mekler, Julia Ayumi Bopp, Alexandre N Tuch, and Klaus Opwis. A systematic review of quantitative studies on the enjoyment of digital entertainment games. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 927–936, 2014.

[163] DR Michael and S Chen. Serious games: Games that educate, train and inform. 2nd, 2006.

[164] Laurent Michaud and Julian Alvarez. Serious games: Advergaming, edugaming, training and more. *IDATE Consulting & Research*, 2008.

[165] James A Middleton, Joan Littlefield, and Richard Lehrer. Gifted students' conceptions of academic fun: An examination of a critical construct for gifted education. *Gifted Child Quarterly*, 36(1):38–44, 1992.

[166] Leslie M Miller, Ching-I Chang, Shu Wang, Margaret E Beier, and Yvonne Klisch. Learning and motivational impacts of a multimedia science game. *Computers & Education*, 57(1):1425–1433, 2011.

[167] Alice Mitchell and Carol Savill-Smith. The use of computer and video games for learning. *A review of the literature*, 2004.

[168] Moderator:, Ross Shegog, Participants:, Katherine Brown, Sheana Bull, John L Christensen, Kimberly Hieftje, Kristen N Jozkowski, and Michele L Ybarra. Serious games for sexual health. *Games for health journal*, 4(2):69–77, 2015.

[169] Jonathan Moizer, Jonathan Lean, Elena Dell'Aquila, Paul Walsh, Alphonsus Alfie Keary, Deirdre O'Byrne, Andrea Di Ferdinando, Orazio Miglino, Ralf Friedrich, Roberta Asperges, et al. An approach to evaluating the user experience of serious games. *Computers & Education*, 136:141–151, 2019.

[170] Sebastian Möller, Steven Schmidt, and Justus Beyer. Gaming taxonomy: An overview of concepts and evaluation methods for computer gaming qoe. In *2013 Fifth International Workshop on Quality of Multimedia Experience (QoMEX)*, pages 236–241. IEEE, 2013.

[171] Diego Monteiro, Hai-Ning Liang, Andrew Abel, Nilufar Bahaei, and Rita de Cassia Monteiro. Evaluating engagement of virtual reality games based on first and third person perspective using eeg and subjective metrics. In *2018 IEEE international conference on artificial intelligence and virtual reality (AIVR)*, pages 53–60. Ieee, 2018.

[172] David R Moore, Joy F Rosenberg, and John S Coleman. Discrimination training of phonemic contrasts enhances phonological processing in mainstream school children. *Brain and language*, 94(1):72–85, 2005.

[173] Julie D Moreland, Julie A Richardson, Charlie H Goldsmith, and Catherine M Clase. Muscle weakness and falls in older adults: a systematic review and meta-analysis. *Journal of the American Geriatrics Society*, 52(7):1121–1129, 2004.

[174] Kira Morrow, Ciprian Docan, Grigore Burdea, and Alma Merians. Low-cost virtual rehabilitation of the hand for patients post-stroke. In *2006 international workshop on virtual rehabilitation*, pages 6–10. IEEE, 2006.

[175] Fausto Mourato, Manuel Próspero dos Santos, and Fernando Birra. Automatic level generation for platform videogames using genetic algorithms. In *Proceedings of the 8th International Conference on Advances in Computer Entertainment Technology*, pages 1–8, 2011.

[176] Mathieu Muratet, Fabienne Viallet, Patrice Torguet, and Jean-Pierre Jessel. Une ingénierie pour jeux sérieux. In *EIAH 2009*, pages 53–63, 2009.

[177] Curtiss Murphy. Why games work and the science of learning. In *Selected Papers Presented at MODSIM World 2011 Conference and Expo*, 2012.

[178] Lennart E Nacke. Wiimote vs. controller: electroencephalographic measurement of affective gameplay interaction. In *Proceedings of the international academic conference on the future of game design and technology*, pages 159–166, 2010.

[179] Lennart Erik Nacke, Michael Kalyn, Calvin Lough, and Regan Lee Mandryk. Biofeedback game design: using direct and indirect physiological control to enhance game interaction. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 103–112, 2011.

[180] Henk H Nap, YAW De Kort, and Wijnand A IJsselsteijn. Senior gamers: preferences, motivations and needs. *Gerontechnology*, 8(4):247–262, 2009.

[181] Xenija Neufeld, Sanaz Mostaghim, and Diego Perez-Liebana. Procedural level generation with answer set programming for general video game playing. In *2015 7th Computer Science and Electronic Engineering Conference (CEEC)*, pages 207–212. IEEE, 2015.

[182] A Imran Nordin, Alena Denisova, and Paul Cairns. Too many questionnaires: measuring player experience whilst playing digital games. 2014.

[183] Kent L Norman. Geq (game engagement/experience questionnaire): a review of two papers. *Interacting with computers*, 25(4):278–283, 2013.

[184] Diana G. Oblinger. Simulations, games, and learning [online]. *ELI White Paper*, 1(1), 2006. Accessed: 18-11-2021.

[185] World Health Organization et al. *International classification of impairments, disabilities, and handicaps: a manual of classification relating to the consequences of disease, published in accordance with resolution WHA29. 35 of the Twenty-ninth World Health Assembly, May 1976.* World Health Organization, 1980.

[186] Brad Paras. Game, motivation, and effective learning: An integrated model for educational game design. In *Proceedings of DiGRA 2005 conference: Changing views - worlds in play*, 2005.

[187] Janne Parkkila, Filip Radulovic, Daniel Garijo, María Poveda-Villalón, Jouni Ikonen, Jari Porras, and Asunción Gómez-Pérez. An ontology for videogame interoperability. *Multimedia tools and applications*, 76(4):4981–5000, 2017.

[188] Avinash Parnandi, Beena Ahmed, Eva Shipp, and Ricardo Gutierrez-Osuna. Chill-out: Relaxation training through respiratory biofeedback in a mobile casual game. In *International Conference on Mobile Computing, Applications, and Services*, pages 252–260. Springer, 2013.

[189] Marco Pasch, Nadia Bianchi-Berthouze, Betsy van Dijk, and Anton Nijholt. Movement-based sports video games: Investigating motivation and gaming experience. *Entertainment computing*, 1(2):49–61, 2009.

[190] Daniela CC Peixoto, Rodolfo F Resende, and Clarindo Isaías PS Pádua. Evaluating software engineering simulation games: The ugalco framework. In *2014 IEEE Frontiers in Education Conference (FIE) Proceedings*, pages 1–9. IEEE, 2014.

[191] Arttu Perttula, Kristian Kiili, Antero Lindstedt, and Pauliina Tuomi. Flow experience in game based learning–a systematic literature review. 2017.

[192] Panagiotis Petridis, Ian Dunwell, David Panzoli, Sylvester Arnab, Aristidis Protopsaltis, Maurice Hendrix, and Sara de Freitas. Game engines selection framework for high-fidelity serious applications. *International Journal of Interactive Worlds*, pages Article–ID, 2012.

[193] David Pinelle, Nelson Wong, and Tadeusz Stach. Heuristic evaluation for games: usability principles for video game design. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 1453–1462, 2008.

[194] Karolien Poels, Yvonne De Kort, and Wijnand Ijsselsteijn. "it is always a lot of fun!" exploring dimensions of digital game experience using focus group methodology. In *Proceedings of the 2007 conference on Future Play*, pages 83–89, 2007.

[195] Jason Power, Raymond Lynch, and Oliver McGarr. Difficulty and self-efficacy: An exploratory study. *British Journal of Educational Technology*, 51(1):281–296, 2020.

[196] Marc Prensky. Fun, play and games: What makes games engaging. *Digital game-based learning*, 5(1):5–31, 2001.

[197] Marc Prensky. The games generations: How learners have changed. *Digital game-based learning*, 1(1):1–26, 2001.

[198] Marc Prensky. The motivation of gameplay: The real twenty-first century learning revolution. *On the horizon*, 2002.

[199] Marc R Prensky. *From digital natives to digital wisdom: Hopeful essays for 21st century learning.* Corwin Press, 2012.

[200] Adrian Radillo. L'expérimentation de l'utilisation des jeux vidéo en remédiation cognitive (experimentation on videogames use in cognitive remediation). *Enfances Psy*, (3):174–179, 2009.

[201] Adrian Ramcharitar and Robert J Teather. A fitts' law evaluation of video game controllers: thumbstick, touchpad and gyrosensor. In *Proceedings of the 2017 chi conference extended abstracts on human factors in computing systems*, pages 2860–2866, 2017.

[202] Pei-Luen Patrick Rau, Shu-Yun Peng, and Chin-Chow Yang. Time distortion for expert and novice online game players. *CyberPsychology & Behavior*, 9(4):396–403, 2006.

[203] Elaine M Raybourn. Applying simulation experience design methods to creating serious game-based adaptive training systems. *Interacting with computers*, 19(2):206–214, 2007.

[204] Paula Rego, Pedro Miguel Moreira, and Luis Paulo Reis. Serious games for rehabilitation: A survey and a classification towards a taxonomy. In *5th Iberian conference on information systems and technologies*, pages 1–6. IEEE, 2010.

[205] Mitchel Resnick. Edutainment? no thanks. i prefer playful learning. *Associazione Civita Report on Edutainment*, 14:1–4, 2004.

[206] Lloyd P Rieber and David Noah. Games, simulations, and visual metaphors in education: antagonism between enjoyment and learning. *Educational Media International*, 45(2):77–92, 2008.

[207] Jacob M Rigby, Duncan P Brumby, Sandy JJ Gould, and Anna L Cox. Development of a questionnaire to measure immersion in video media: The film ieq. In *Proceedings of the 2019 ACM International Conference on Interactive Experiences for TV and Online Video*, pages 35–46, 2019.

[208] Scott Rigby and Richard M Ryan. *Glued to games: How video games draw us in and hold us spellbound: How video games draw us in and hold us spellbound*. AbC-CLIo, 2011.

[209] Ute Ritterfeld, Michael Cody, and Peter Vorderer. *Serious games: Mechanisms and effects*. Routledge, 2009.

[210] Ute Ritterfeld and Rene Weber. Video games for entertainment and education, p. vorderer, j bryant (eds.) playing video games–motives, responses, and conseguences, 2006.

[211] Lisa Robinson, Pam Dawson, and Julia Newton. Promoting adherence with exercise-based falls prevention programmes. 2008.

[212] Andrew Rollings and Ernest Adams. *Andrew Rollings and Ernest Adams on game design*. New Riders, 2003.

[213] Richard Rouse III. *Game design: Theory and practice*. Jones & Bartlett Publishers, 2004.

[214] Laurence Z Rubenstein. Falls in older people: epidemiology, risk factors and strategies for prevention. *Age and ageing*, 35(suppl_2):ii37–ii41, 2006.

[215] Carmen V Russoniello, Kevin O'Brien, and Jennifer M Parks. Eeg, hrv and psychological correlates while playing bejeweled ii: A randomized controlled study. *Annual review of cybertherapy and telemedicine*, 7(1):189–192, 2009.

[216] Richard M Ryan and Edward L Deci. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American psychologist*, 55(1):68, 2000.

[217] Richard M Ryan, Edward L Deci, et al. Overview of self-determination theory: An organismic dialectical perspective. *Handbook of self-determination research*, 2:3–33, 2002.

[218] Richard M Ryan, C Scott Rigby, and Andrew Przybylski. The motivational pull of video games: A self-determination theory approach. *Motivation and emotion*, 30(4):344–360, 2006.

[219] Jennifer L Sabourin and James C Lester. Affect and engagement in game-based learning environments. *IEEE transactions on affective computing*, 5(1):45–56, 2013.

[220] Kavous Salehzadeh Niksirat, Chaklam Silpasuwanchai, Mahmoud Mohamed Hussien Ahmed, Peng Cheng, and Xiangshi Ren. A framework for interactive mindfulness meditation using attention-regulation process. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, pages 2672–2684, 2017.

[221] José Luis González Sánchez, Francisco L Gutiérrez, Marcelino Cabrera, and Natalia Padilla Zea. Design of adaptative video game interfaces: a practical case of use in special education. In *Computer-aided design of user interfaces VI*, pages 71–76. Springer, 2009.

[222] Timothy A Sanders and Paul Cairns. Time perception, immersion and music in videogames. 2010.

[223] Claudia Schrader and Theo J Bastiaens. The influence of virtual presence: Effects on experienced cognitive load and learning outcomes in educational computer games. *Computers in Human Behavior*, 28(2):648–658, 2012.

[224] SG Senevirathne, M Kodagoda, V Kadle, Steve Haake, T Senior, and BW Heller. Application of serious games to sport, health and exercise. In *Proceedings of the 6th SLIIT Research Symposium*. Centre for Sports Engineering Research (Does not include content added after October 2018), January 2011.

[225] Noor Shaker, Julian Togelius, and Mark J Nelson. *Procedural content generation in games*. Springer, 2016.

[226] Cuihua Shen, Hua Wang, and Ute Ritterfeld. Serious games and seriously fun games: Can they be one and the same? In *Serious Games*, pages 70–84. Routledge, 2009.

[227] Nicholas Shim, Ronald Baecker, Jeremy Birnholtz, and Karyn Moffatt. Tabletalk poker: an online social gaming environment for seniors. In *Proceedings of the International Academic Conference on the Future of Game Design and Technology*, pages 98–104, 2010.

[228] Valerie J Shute, Matthew Ventura, Malcolm Bauer, et al. Melding the power of serious games and embedded assessment to monitor and foster learning: Flow and grow. In *Serious games*, pages 317–343. Routledge, 2009.

[229] Jeff Sinclair, Philip Hingston, and Martin Masek. Considerations for the design of exergames. In *Proceedings of the 5th international conference on Computer graphics and interactive techniques in Australia and Southeast Asia*, pages 289–295, 2007.

[230] Mel Slater et al. Measuring presence: A response to the witmer and singer presence questionnaire. *Presence: teleoperators and virtual environments*, 8(5):560–565, 1999.

[231] Jan David Smeddinck, Marc Herrlich, and Rainer Malaka. Exergames for physiotherapy and rehabilitation: A medium-term situated study of motivational aspects and impact on functional reach. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, pages 4143–4146, 2015.

[232] Kurt Squire and Henry Jenkins. Harnessing the power of games in education. *Insight*, 3(1):5–33, 2003.

[233] Kurt D Squire. Video game–based learning: An emerging paradigm for instruction. *Performance Improvement Quarterly*, 21(2):7–36, 2008.

[234] Tarja Susi, M Johanesson, and Per Backlund. Serious games-an overview (technical report). *Skövde, Sweden: University of Skövde*, 2007.

[235] Penelope Sweetser, Daniel Johnson, Peta Wyeth, Aiman Anwar, Yan Meng, and Anne Ozdowska. Gameflow in different game genres and platforms. *Computers in Entertainment (CIE)*, 15(3):1–24, 2017.

[236] Penelope Sweetser and Peta Wyeth. Gameflow: a model for evaluating player enjoyment in games. *Computers in Entertainment (CIE)*, 3(3):3–3, 2005.

[237] Penny Sweetser. Gameflow 2020: 15 years of a model of player enjoyment. In *32nd Australian Conference on Human-Computer Interaction*, pages 705–711, 2020.

[238] Nicolas Szilas and Denise Sutter Widmer. Mieux comprendre la notion d'intégration entre apprentissage et jeu (a better understanding of the concept of integrating learning and play). In *Actes de l'atelier de la 4éme conférence francophone sur les environnements informatiques pour l'Apprentissage humain*, pages 27–39, 2009.

[239] Stephen Tang and Martin Hanneghan. Game content model: an ontology for documenting serious game design. In *2011 Developments in E-systems Engineering*, pages 431–436. IEEE, 2011.

[240] Laurie N Taylor. Video games: Perspective, point-of-view, and immersion. 2002.

[241] Matt Thompson, A Imran Nordin, and Paul Cairns. Effect of touch–screen size on game immersion. In *The 26th BCS Conference on Human Computer Interaction 26*, pages 280–285, 2012.

[242] Henrik Thovtrup and Jakob Nielsen. Assessing the usability of a user interface standard. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 335–341, 1991.

[243] Morten Tollefsen and Are Flyen. Internet and accessible entertainment. In *International Conference on Computers for Handicapped Persons*, pages 396–402. Springer, 2006.

[244] Javier Torrente, Ángel del Blanco, Pablo Moreno-Ger, Iván Martínez-Ortiz, and Baltasar Fernández-Manjón. Implementing accessibility in educational videogames with <e-adventure>. In *Proceedings of the first ACM international workshop on Multimedia technologies for distance learning*, pages 57–66, 2009.

[245] Alex (TychoBolt). Level design: In pursuit of better levels [online document]. `https://heystacks.org/doc/345/ld---in-pursuit-of-better-levels`, June 2020. (Accessed: Nov. 2021).

[246] Anders Tychsen, Jonas Heide Smith, Michael Hitchens, and Susana Tosca. Communication in multi-player role playing games–the effect of medium. In *International Conference on Technologies for Interactive Digital Storytelling and Entertainment*, pages 277–288. Springer, 2006.

[247] DH Uttal. Meadow ng. tipton e. hand ll. alden ar. warren c. newcombe ns. *The malleability of spatial skills: a meta-analysis of training studies. Psychol Bull*, 139:352–402, 2013.

[248] Stephen Uzor, Lynne Baillie, and Dawn Skelton. Senior designers: empowering seniors to design enjoyable falls rehabilitation tools. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 1179–1188, 2012.

[249] Roland Van Der Linden, Ricardo Lopes, and Rafael Bidarra. Procedural generation of dungeons. *IEEE Transactions on Computational Intelligence and AI in Games*, 6(1):78–89, 2013.

[250] Richard Van Eck. Digital game-based learning: It's not just the digital natives who are restless. *EDUCAUSE review*, 41(2):16, 2006.

[251] Martijn Van Welie, Gerrit C Van Der Veer, and Anton Eliëns. Patterns as tools for user interface design. In *Tools for Working with Guidelines*, pages 313–324. Springer, 2001.

[252] M van Veen. *Improving collaboration with raketeer: development of a serious game with multi-touch interaction for teaching children with PDD-NOS collaboration.* PhD thesis, Faculty of Science and Engineering, 2009.

[253] Matthew Ventura, Valerie Shute, and Weinan Zhao. The relationship between video game use and a performance-based measure of persistence. *Computers & Education*, 60(1):52–58, 2013.

[254] Rodrigo Vicencio-Moreira, Regan L Mandryk, and Carl Gutwin. Now you can compete with anyone: Balancing players of different skill levels in a first-person shooter game. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, pages 2255–2264, 2015.

[255] Rodrigo Vicencio-Moreira, Regan L Mandryk, Carl Gutwin, and Scott Bateman. The effectiveness (or lack thereof) of aim-assist techniques in first-person shooter games. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 937–946, 2014.

[256] Wim Westera, RJ Nadolski, Hans GK Hummel, and Iwan GJH Wopereis. Serious games for higher education: a framework for reducing design complexity. *Journal of Computer Assisted Learning*, 24(5):420–432, 2008.

[257] Robert W White. Motivation reconsidered: the concept of competence. *Psychological review*, 66(5):297, 1959.

[258] Glenn Joseph Winters and Jichen Zhu. Guiding players through structural composition patterns in 3d adventure games. In *FDG*, 2014.

[259] Jeffrey Wiseman, Emmanuel G Blanchard, and Susanne Lajoie. The deteriorating patient smartphone app: Towards serious game design. In *Educational Technologies in Medical and Health Sciences Education*, pages 215–234. Springer, 2016.

[260] Bob G Witmer and Michael J Singer. Measuring presence in virtual environments: A presence questionnaire. *Presence*, 7(3):225–240, 1998.

[261] Mark JP Wolf. *The medium of the video game*. University of Texas Press, 2002.

[262] Wee Ling Wong, Cuihua Shen, Luciano Nocera, Eduardo Carriazo, Fei Tang, Shiyamvar Bugga, Harishkumar Narayanan, Hua Wang, and Ute Ritterfeld. Serious video game effectiveness. In *Proceedings of the international conference on Advances in computer entertainment technology*, pages 49–55, 2007.

[263] Aileen Worden, Nef Walker, Krishna Bharat, and Scott Hudson. Making computers easier for older adults to use: area cursors and sticky icons. In *Proceedings of the ACM SIGCHI Conference on Human factors in computing systems*, pages 266–271, 1997.

[264] Cory Wright-Maley. Beyond the "babel problem": Defining simulations for the social studies. *The Journal of Social Studies Research*, 39(2):63–77, 2015.

[265] Maja Wrzesien and Mariano Alcañiz Raya. Learning in serious virtual worlds: Evaluation of learning effectiveness and appeal to students in the e-junior project. *Computers & Education*, 55(1):178–187, 2010.

[266] Yin Wu. *The style of video games graphics: analyzing the functions of Visual styles in storytelling and gameplay in video games*. PhD thesis, Communication, Art & Technology: School of Interactive Arts and Technology, 2012.

[267] Georgios N Yannakakis and Julian Togelius. Experience-driven procedural content generation. In *2015 International Conference on Affective Computing and Intelligent Interaction (ACII)*, pages 519–525. IEEE, 2015.

[268] Derek Yu. *Spelunky: Boss Fight Books# 11*, volume 11. Boss Fight Books, 2016.

[269] Bei Yuan, Eelke Folmer, and Frederick C Harris. Game accessibility: a survey. *Universal Access in the information Society*, 10(1):81–100, 2011.

[270] Alexander Zaranek, Bryan Ramoul, Hua Fei Yu, Yiyu Yao, and Robert J Teather. Performance of modern gaming input devices in first-person shooter target acquisition. In *CHI'14 Extended Abstracts on Human Factors in Computing Systems*, pages 1495–1500. New York: ACM., 2014.

[271] Michael Zyda. From visual simulation to virtual reality to games. *Computer*, 38(9):25–32, 2005.

# Non-Scientific references


[NS1] Openttd [online]. https://www.openttd.org/. (Accessed: 18-11-2021).

[NS2] Kevin Bierre. Improving game accessibility [online]. *Gamasutra Feature Article*, 2005. (Accessed: 19-12-2021).

[NS3] Ross Bramble. The ultimate guide to 2d video game art styles [online]. https://gamemaker.io/en/blog/2d-game-art-styles, April 2022. (Accessed: 13-09-2022).

[NS4] Josh Bycer. 3 failings of procedurally generated game design [online]. https://game-wisdom.com/critical/procedural-game-design, August 2016. (Accessed: 13-12-2021).

[NS5] Heather Robertson (Game Design Conference). Procedural regeneration: Matching the world to the player [online]. https://www.youtube.com/watch?v=rf4VaRldwOY&ab_channel=GDC, August 2020. (Accessed: 23-12-2021).

[NS6] International Roguelike Development Conference. Berlin interpretation — roguebasin [online]. http://www.roguebasin.com/index.php?title=Berlin_Interpretation, September 2008. (Accessed: 16-09-2022).

[NS7] Jon Ingold (Game Design Conference). Narrative sorcery: Coherent storytelling in an open world [online]. https://www.youtube.com/watch?v=HZft_U4Fc-U&t=1s&ab_channel=GDC, December 2020. (Accessed: 16-01-2022).

[NS8] Justin Fischer (Game Design Conference). Why dark souls is the 'ikea' of games [online]. https://www.youtube.com/watch?v=vid5yZRKzs0&ab_channel=GDC, February 2019. (Accessed: 13-07-2022).

[NS9] Kate Compton (Game Design Conference). Practical procedural generation for everyone [online]. https://www.youtube.com/watch?v=WumyfLEa6bU&ab_channel=GDC, May 2017. (Accessed: 23-12-2021).

[NS10] Lisa Brown (Game Design Conference). Applying 3d level design skills to the 2d world of hyper light drifter [online]. https://www.youtube.com/watch?v=LFsMenc5Q8I&ab_channel=GDC, September 2017. (Accessed: 30-12-2021).

[NS11] Mark Ferrari (Game Design Conference). 8 bit & '8 bitish' graphics-outside the box [online]. https://www.youtube.com/watch?v=aMcJ1Jvtef0&ab_channel=GDC, January 2017. (Accessed: 28-12-2021).

[NS12] Tyriq Plummer (Game Design Conference). 2d animation for games: A primer [online]. https://www.youtube.com/watch?v=PKZJmHrG4Yw&ab_channel=GDC, January 2022. (Accessed: 22-02-2022).

[NS13] William Pugh (Game Design Conference). How to make your game just completely hilarious: The stanley parable [online]. https://www.youtube.com/watch?v=pLbmZT7OrtA&t=1516s&ab_channel=GDC, March 2015. (Accessed: 06-12-2021).

[NS14] Daniel Cook. Understanding randomness in terms of mastery [online]. https://lostgarden.home.blog/2012/12/31/understanding-randomness-in-terms-of-mastery/, December 2012. (Accessed: 03-01-2022).

[NS15] Zayne Black (Let's Talk Game Design). 2d platformer level design with bob ross - devlog 7 [online]. https://www.youtube.com/watch?v=soalj7QuszI&ab_channel=Let%27sTalkGameDesign, December 2020. (Accessed: 20-01-2022).

[NS16] Zayne Black (Let's Talk Game Design). How to level design in 2d platformers - devlog 6 [online]. https://www.youtube.com/watch?v=ce8cum_mnKA&ab_channel=Let%27sTalkGameDesign, November 2020. (Accessed: 29-12-2021).

[NS17] Zayne Black (Let's Talk Game Design). How to make game graphics when you're bad at art - devlog 2 [online]. https://www.youtube.com/watch?v=wiDOCYhzIHI&ab_channel=Let%27sTalkGameDesign, October 2020. (Accessed: 12-01-2022).

[NS18] Zayne Black (Let's Talk Game Design). Making and releasing my first steam game - devlog 1 [online]. https://www.youtube.com/watch?v=74SevIHoDxU&ab_channel=Let%27sTalkGameDesign, October 2020. (Accessed: 12-01-2022).

[NS19] Zayne Black (Let's Talk Game Design). What is this game even about?! - devlog 3 [online]. https://www.youtube.com/watch?v=OPR4hXaKDSc&list=PLbelkP-HkwvDfJoSURZtP5DX6PlnbPlhV&index=4, November 2020. (Accessed: 28-12-2021).

[NS20] Zayne Black (Let's Talk Game Design). Advanced level design techniques in 2d platformers - devlog 8 [online]. https://www.youtube.com/watch?v=GbcAk1DwcOk&list=PLbelkP-HkwvDfJoSURZtP5DX6PlnbPlhV&index=11&ab_channel=Let%27sTalkGameDesign, January 2021. (Accessed: 20-01-2022).

[NS21] Designing Digitally. Different types of serious games [online]. https://www.designingdigitally.com/blog/different-types-of-serious-games, August 2019. (Accessed: 18-11-2021).

[NS22] Microsoft, Xbox.com, Warfighter Engaged, Cerebral Palsy Foundation, AbleGamers, Special Effect. Xbox adaptive controller [online]. https://www.xbox.com/nl-NL/accessories/controllers/xbox-adaptive-controller, November 2021. (Accessed: 16-12-2021).

[NS23] Eelke Folmer. Designing usable and accessible games with interaction design patterns [online]. *Gamasutra Feature Article*, May 2007. (Accessed: 19-12-2021).

[NS24] gameaccessibilityguidelines.com. How ubisoft is putting the spotlight on accessibility [online]. https://news.ubisoft.com/en-us/article/1etr8zW1Vo6XCehOUM5KJO/how-ubisoft-is-putting-the-spotlight-on-accessibility, May 2018. (Accessed: 09-12-2021).

[NS25] gameaccessibilityguidelines.com. Game accessibility guidelines: A straightforward reference for inclusive game design [online]. http://gameaccessibilityguidelines.com/full-list/, Dec 2021. (Accessed: 08-12-2021).

[NS26] Bay 12 Games. Bay 12 games: Dwarf fortress [online]. (Accessed: 10-11-2022).

[NS27] Grendel Games. Garfield's count me in [online]. https://grendelgames.com/spotlight/garfields-count-me-in/. (Accessed: 18-11-2021).

[NS28] Tim Laning (Grendel Games). What are the five types of serious games? [online]. https://grendelgames.com/what-are-the-five-types-of-serious-games/, January 2021. (Accessed: 18-11-2021).

[NS29] Brad (Snoman Gaming). Good game design - super meat boy: Motivational punishment [online]. https://www.youtube.com/watch?v=JeSvCmaZUjA&ab_channel=SnomanGaming, September 2015. (Accessed: 1-11-2021).

[NS30] James Paul Gee. High score education [online]. May 2003. (Accessed: 05-10-2022).

[NS31] Dimitris Grammenos and Anthony Savidis. Unified design of universally accessible games (say what?) [online]. *Gamasutra Feature article*, December 2006. (Accessed: 19-12-2021).

[NS32] GrowthEngineering.com. 10 serious games that changed the world [online]. https://www.growthengineering.co.uk/10-serious-games-that-changed-the-world/, March 2016. (Accessed: 18-11-2021).

[NS33] IGN. Top 100 video games of all time [online]. https://www.ign.com/lists/top-100-games/100, October 2019. (Accessed: 14-12-2021).

[NS34] Foraker Labs. Glossary - playability [online]. 2012. (Accessed: 30-09-2022).

[NS35] Noel Berry Mark Brown (Game Makers ToolKit), Maddy Thorson (Matt at time of recording). Why does celeste feel so good to play? [online]. https://www.youtube.com/watch?v=yorTG9at90g&ab_channel=GameMaker%27sToolkit, July 2019. (Accessed: 17-09-2022).

[NS36] Matthew Matosis (Matthewmatosis). The lost soul arts of demon's souls [online]. https://www.youtube.com/watch?v=Np5PdpsfINA&ab_channel=Matthewmatosis, June 2017. (Accessed: 25-09-2021).

[NS37] (Extra Credits) Max Pears. So you want to be a level designer - an introduction to level design in video games - extra credits [online]. https://www.youtube.com/watch?v=pNvUWHquSHc&ab_channel=ExtraCredits, August 2021. (Accessed: 29-12-2021).

[NS38] Adam Millard (Adam Millard The Architect of Games). 6 lessons from hollow knight's immersive tutorial [online]. https://www.youtube.com/watch?v=vWiDS8SUvds&ab_channel=AdamMillard-TheArchitectofGames, July 2017. (Accessed: 20-10-2021).

[NS39] Adam Millard (Adam Millard The Architect of Games). The hollow hardcore - mastering the art of flow [online]. https://www.youtube.com/watch?v=vpmZvblY_vU&ab_channel=AdamMillard-TheArchitectofGames, October 2017. (Accessed: 01-11-2021).

[NS40] Adam Millard (Adam Millard The Architect of Games). How videogames keep you playing forever [online]. https://www.youtube.com/watch?v=woAiDiH_Y8Q&ab_channel=AdamMillard-TheArchitectofGames, December 2021. (Accessed: 23-12-2021).

[NS41] Adam Millard (Adam Millard The Architect of Games). How videogames keep you playing forever [online]. https://www.youtube.com/watch?v=woAiDiH_Y8Q&ab_channel=AdamMillard-TheArchitectofGames, December 2021. (Accessed: 23-12-2021).

[NS42] Vince Palban. Managing difficulty in games. *Game Design & Development 2021*, 2021. (Accessed: 07-12-2021).

[NS43] UPS project and MediaLT. Media lt. guidelines for the development of entertaining software for people with multiple learning disabilities [online]. http://www.medialt.no/rapport/entertainment_guidelines/, January 2004. (Accessed: 16-12-2021).

[NS44] Francisco RA. Many faces of procedural generation: Degrees of procgen (classification system, part 2) [online]. https://www.gamedeveloper.com/design/many-faces-of-procedural-generation-degrees-of-procgen-classification-system-part-2-, March 2016. (Accessed: 24-12-2021).

[NS45] Micheal Rougeau. It's possible to finish "dishonored" without killing anyone at all [online]. *Complex Feature Article*, July 2012. (Accessed: 04-12-2022).

[NS46] Sherif Saed. You can finish dishonored 2 without killing anyone [online]. *VG247 Feature Article*, August 2016. (Accessed: 04-12-2022).

[NS47] Tanya Short and Tarn Adams (Game Design Conference). Dwarf fortress, moon hunters, and practices in procedural generation [online]. https://www.youtube.com/watch?v=v8zwPdPvN10&ab_channel=GDC, May 2016. (Accessed: 05-01-2022).

[NS48] Sinclair Strange (SinclairStrange). Let's make games: Level design tips [online]. https://www.youtube.com/watch?v=HU25BJH1PfY&ab_channel=SinclairStrange, December 2018. (Accessed: 29-12-2021).

[NS49] Glen Callaert (ThatGuyGlen). How hollow knight was made and first appeared on newgrounds [online]. https://www.youtube.com/watch?v=kSAlVBFdC6k&ab_channel=ThatGuyGlen, July 2020. (Accessed: 02-11-2021).

[NS50] Mark Brown (Game Makers ToolKit). Redesigning death [online]. https://www.youtube.com/watch?v=6WyalnKQIpg&ab_channel=GameMaker%27sToolkit, March 2015. (Accessed: 01-11-2021).

[NS51] Mark Brown (Game Makers ToolKit). Secrets of game feel and juice [online]. https://www.youtube.com/watch?v=Lx7BWayWu08&ab_channel=GameMaker%27sToolkit, February 2015. (Accessed: 09-03-2021).

[NS52] Mark Brown (Game Makers ToolKit). Shovel knight and nailing nostalgia [online]. https://www.youtube.com/watch?v=rHhX5GtWNr8&ab_channel=GameMaker%27sToolkit, August 2016. (Accessed: 04-02-2022).

[NS53] Mark Brown (Game Makers ToolKit). Do we need a soulslike genre? [online]. https://www.youtube.com/watch?v=Lx7BWayWu08&ab_channel=GameMaker%27sToolkit, July 2017. (Accessed: 25-09-2021).

[NS54] Mark Brown (Game Makers ToolKit). Finding the fun in fps campaigns [online]. https://www.youtube.com/watch?v=-Bx5t0baXhc&ab_channel=GameMaker%27sToolkit, January 2017. (Accessed: 13-11-2021).

[NS55] Mark Brown (Game Makers ToolKit). Making games better for gamers with colourblindness & low vision — designing for disability [online]. https://www.youtube.com/watch?v=xrqdU4cZaLw&ab_channel=GameMaker%27sToolkit, August 2018. (Accessed: 08-12-2021).

[NS56] Mark Brown (Game Makers ToolKit). Making games better for players with motor disabilities — designing for disability [online]. https://www.youtube.com/watch?v=Ufe0i26DGiA&ab_channel=GameMaker%27sToolkit, October 2018. (Accessed: 08-12-2021).

[NS57] Mark Brown (Game Makers ToolKit). Making games better for the deaf and hard of hearing — designing for disability [online]. youtube.com/watch?v=4NGe4dzlukc&ab_channel=GameMaker%27sToolkit, July 2018. (Accessed: 08-12-2021).

[NS58] Mark Brown (Game Makers ToolKit). What makes a good puzzle? [online]. https://www.youtube.com/watch?v=zsjC6fa_YBg&ab_channel=GameMaker%27sToolkit, March 2018. (Accessed: 14-12-2021).

[NS59] Mark Brown (Game Makers ToolKit). Improving games for those with cognitive disabilities — designing for disability [online]. https://www.youtube.com/watch?v=ObhvacfIOgO&ab_channel=GameMaker%27sToolkit, February 2019. (Accessed: 08-12-2021).

[NS60] Mark Brown (Game Makers ToolKit). Roguelikes, persistency, and progression [online]. https://www.youtube.com/watch?v=216_5nu4aVQ&ab_channel=GameMaker%27sToolkit, January 2019. (Accessed: 14-01-2022).

[NS61] Mark Brown (Game Makers ToolKit). The world design of hollow knight — boss keys [online]. https://www.youtube.com/watch?v=7ITtPPE-pXE&ab_channel=GameMaker%27sToolkit, October 2019. (Accessed: 08-04-2021).

[NS62] Mark Brown (Game Makers ToolKit). Designing for disability - playlist [online]. https://www.youtube.com/playlist?list=PLc38fcMFcV_vvWOhMDriBlVocTZ8mKQzR, December 2020. (Accessed: 08-12-2021).

[NS63] Mark Brown (Game Makers ToolKit). Who gets to be awesome in games? [online]. https://www.youtube.com/watch?v=XSvclSkmdyY&ab_channel=GameMaker%27sToolkit, October 2020. (Accessed: 21-11-2021).

[NS64] Sebastien Benard (Motion Twin). Building the level design of a procedurally generated metroidvania: a hybrid approach. [online]. https://www.gamedeveloper.com/design/building-the-level-design-of-a-procedurally-generated-metroidvania-a-hybrid-approach-, March 2017. (Accessed: 20-10-2021).

[NS65] J.S. Webster (Webster). Why accessibility in gaming is important [online]. https://www.youtube.com/watch?v=zRedkc7_gE0&ab_channel=Webster, December 2020. (Accessed: 27-09-2021).

[NS66] NetHack Wiki. Glossary - ascension [online]. https://nethackwiki.com/wiki/Ascension. (Accessed: 14-09-2022).

[NS67] Wikipedia. Serious game [online]. https://en.wikipedia.org/wiki/Serious_game. (Accessed: 18-11-2021).

[NS68] Erik Wolpaw and Jeff Felsic (Game Design Conference). Portal 2: Creating a sequel to a game that doesn't need one [online]. https://www.youtube.com/watch?v=BYFvwbby2YM&t=2301s&ab_channel=GDC, September 2016. (Accessed: 25-11-2021).