Comparing Break Types for Spaced Practice in a Platformer Game

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Abstract

The progressive development of in-game skills is important to both game players and designers. Players want to get better at games, while designers want to understand and support player progress. These goals align as skill development leads to heightened player performance, which is associated with positive player experiences. When players gain skill at a consistent pace, they tend to enjoy the game more. One promising area of research relates to the spaced practice effect (i.e., taking intentional breaks between periods of doing an activity). Spaced practice has been shown to improve skills in domains unrelated to digital games, such as athletics, and learning. Spaced practice refers to taking consistent breaks between periods of doing an activity. While there is some research into the area of spaced practice in games, it is unclear if the benefits of spaced practice apply in complex games that combine several skills and elements. If the goal of players and designers is to increase the overall quality of the player experience, there are also several issues with forcing the player to take breaks. For example, most players do not like gameplay sessions being interrupted. Taking breaks serves as an interruption to gameplay, and could potentially hinder the player experience. However, games often contain some natural rest periods—if breaks were implemented into the gameplay itself, players may be able to benefit from the spaced practice effect and not have their game interrupted. Some ecologically valid break-like activities are already present in games that could allow for spaced practice (e.g., cutscenes, mini-games, leaderboards, loading screens). Before designers can implement activities as breaks for spaced practice, we first need to know whether engaging with these activities as breaks reduces the benefits of spaced practice. We built a custom 2D platform game in which a player controlled avatar can wall-jump, swing, via a grapple hook and double-jump through an obstacle course. This game was used as the core gameplay activity in two experiments—one to test if spaced practice improves performance in a complex game, and another to determine how spaced practice is affected by the choice of in-game break activity. Through these experiments, we evidence that spaced practice significantly improves skill development in a complex platformer game; that spaced practice is effective across several types of ecologically-valid break activities; and that the use of short breaks does not subvert flow states during play. This supports that the use of spaced practice in games is beneficial. We further contribute some design guidelines for how to implement break activities.

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List of Abbreviations

ACS	Attention Control Scale
ANOVA	Analysis of Variance
FKS	Flow Short Scale
FPS	First-Person Shooter
IMI	Intrinsic Motivation Inventory
LOF	List of Figures
LOT	List of Tables
MANCOVA	Multivariate Analysis of Covariance
MTurk	Mechanical Turk
NPC	Non-Player Character
RM-ANCOVA	Repeated Measures Analysis of Covariance
RPG	Role-Playing Game
SOQ	Sport Orientation Questionnaire

1 Introduction

1.1 Problem and Motivation

With the rise of esports, the increasing popularity of streaming games and a growing demographic of video game players who want more challenging games, the need to understand how players develop in-game skills has become increasingly important. The development of player skill is a topic of great interest to games designers, and is also important for both casual and professional players. Players want to get better, while designers want to support and understand player progress. These goals align, as the facilitation of skill development is associated with a variety of positive player experiences, such as self perceived competence [68] and flow states [25]. To create a positive gameplay experience for players, it is necessary to understand skill acquisition.

One way that players get better at games is by practicing skills through repetition. When players attempt a difficult challenge and fail, they can use the experience gained through that attempt on future attempts. Therefore repetition serves as a way to develop in-game skills [40, 23, 83]. Repeating this over a period of time with no breaks or rests is referred to as continuous practice. While this method of practice is somewhat intuitive, it does have several limitations. Players usually associate negative emotions, such as sadness or anger, with poor performance [12]. If the player is constantly attempting a section of a game and not succeeding, this can cause the player to self evaluate a poor performance in the game and have a worse experience. This lack of proper skill progression can cause the player to become frustrated and potentially quit playing the game [79, 68]. Partially associated with this frustration, continuous play could also cause the player to become burnt-out on the game, due to it becoming less stimulating or seeming too repetitive [90, 13, 52]. Finally, continuous play could cause players to view the game more as a chore rather than a leisure activity [102]. One technique that has been shown to improve several kinds of skills is the idea of spaced practice [76, 50, 28]. This technique suggests that taking breaks between task sessions leads to improved acquisition of a skill and better immediate performance compared to continuous practice.

However, people tend to have a preference for continuous practice [96], and this preference has been observed in game contexts as well [46]. Players often mock suggestions to take breaks and often want to retry challenges immediately after failure [46]. In addition to player preferences about avoiding breaks, there are valid concerns about breaks interfering with the intense focus and concentration that is necessary to induce positive player experiences, such as flow states. While studies have shown spaced practice works in game environments [46, 57, 80, 45], there is little information on how to implement spaced practice into games or how to make a break experience players will enjoy.

There are three major gaps in our knowledge about spaced practice and its effects in video games. First, **we do not know if the benefits of spaced practice apply in complex video games**. The studies demonstrating this effect in games have used relatively simple games, including a variation of *Breakout* [9, 57], a variation of *Asteroids* [27, 80], and a clone of *Super Hexagon* [19, 46]. Research has shown that spaced practice is not as effective for complex skills [101, 61, 28], so it may be that the technique does not apply in cases where the game involves multiple skills to learn. While another study observed spaced practice effects in a complex commercial game, it was an observation of millions of players in the real world with no control for external factors and extremely long break times, often over days [45]. This does not provide any evidence that spaced practice in shorter intervals would provide any benefit in a complex game. Second, **little is known about what players ought to do during breaks** or how a break may affect flow. Break-like activities are already present in games, such as cutscenes, mini-games, inventory management, player statistics presentations, or free play environments. We suggest that designers should implement these activities in a way that utilizes spaced practice. When compared to an explicit rest, they can keep players engaged with the game while providing a break from the primary game task, preserving flow while giving players the necessary performance gains to succeed at the game. Alternatively, it is not clear whether in-game breaks will interfere with the underlying mechanism of spaced practice, for example, by being too demanding or too similar to the primary game task. This leads to the final gap in our knowledge, **we do not know how breaks or break activities affect the player experience.** As outlined previously, there are studies demonstrating spaced practice in games, very few provide insight on how players experience the breaks. Only one study makes mention of measuring player experience [46] where they found a marginal difference in enjoyment between the continuous practice group and 2-minute spaced practice group. The experience portion of this study was not the main focus however, and does not provide a conclusion on whether players like taking breaks.

Therefore, in this thesis, to address these gaps in knowledge we conduct multiple studies to answer the following three questions:

1. Does spaced practice work in a more complex game?
2. Does the type of break activity affect the player performance?
3. Do breaks and different break activities interrupt flow?

1.2 Solution

To address whether the spaced practice effect works in complex video games, we created a side scrolling 2D platformer game. Platformers when compared to other video game genres, such as First-Person Shooters (FPS) or Role-Playing Games (RPG), are not as complex in mechanics or goals. A 2D platformer served as a good next step from games used in prior research [46, 57, 27, 80]. We were able to implement several mechanics that engaged the player and made them use multiple skills. The use of these skills by the player involves a number of distinct actions that must be coordinated, which increases game complexity. It was also simple enough to make a game that felt somewhat familiar while also being suitable for data collection.

A 2D platformer also worked well in addressing our second question, whether different break types affect the benefits of spaced practice in games. With a 2D platformer, we could implement several different breaks types, such as loading screens, cut scenes, and various minigames, seamlessly into the flow of the game without them feeling jarring or out of place.

However, in order to determine which breaks would be suitable for the study, we needed to create a framework to categorize breaks. We made the assumption that if a break is too similar to the main task, it would not be different enough from the main task and still act like continuous practice. We also made the assumption that if breaks had more distinct actions, pressure, and stimuli, that would negate the effects of the breaks as it would not act like a rest. Based on this, we categorized and created breaks for our platformer based on varying degrees of task similarity and task intensity.

1.3 Steps to Solution

There were many steps in the process to understand how spaced practice works in video games and how breaks may influence the benefits of spaced practice. First we created a platformer that was suitable for observing spaced practice. This platformer had to be a game that required players to increase their skills from novice to expert within a short window. The game had to include skills that players were familiar with, as to not make the game too hard, while also including skills that they were unfamiliar with in order to prevent the game from being too easy. The game also had to have the player repeat the use of these skills in a comparable way, so we could accurately evaluate the performance of the players. Once we created a game that satisfied these conditions, we then had to make sure that the game could easily implement a break system for spaced practice, and then seamlessly have those breaks be a range of gameplay activities.

To meet this criteria, we created a 2D platformer that had players running and jumping (as standard and familiar with most platformers), with a grapple and swing mechanic as a new learned mechanic for players to improve at executing. Players would then have to use these skills through a repeating course, analogous to a lap on a racetrack. Then we implemented a simple blank screen with a timer as a break that could occur between gameplay at a set time. With a system that satisfied our criteria, in Experiment One, we examined whether spaced practice works in a more complex game by comparing spaced practice to continuous practice. Participants completed four 5-minute gameplay segments, broken up by either a 2-minute break (spaced practice) or a 3-second break (continuous practice). The details of the game, study design and results are described fully in Chapter 3.

After running the main experiment task, we ran a retention task one week later to see if the performance gains persisted longer than in the immediate task. After running the main study and retention task, we were able to conclude that spaced practice does work in our game. Participants who played our spaced practice version of the platformer performed better than the continuous practice group of participants.

Based on these results, we could then move onto understanding how breaks influence the benefits of spaced practice. We wanted to implement an encompassing variety of breaks that reflect what would be found in commercial games. We needed to design a framework that was based on existing literature on switching tasks and would reflect what is found in commercial games. After a few iterations, our framework used intensity (the level of interaction needed to conduct the activity) and similarity (how close the activity was to skills needed during the primary game task) as the criteria to compare our breaks. Designing breaks with low and high levels of each factor, resulted in four break types for our game (a dialogue with a Non-Player Character (NPC), a maze mini-game, and a grapple minigame that could be either fast or slow). In Study 2, we used the same platformer to keep our results comparable to Study 1. We had all participants play four 5-minute gameplay segments with 2-minute breaks, similar to in Study 1. However in each 2-minute segment we had one of our four break types for the participant to do while they waited for the break to end. Details of how we designed and implemented our framework, as well as our second study and its results are discussed in Chapter 4.

1.4 Evaluation

We created one level in our platformer and had it repeat seamlessly when players finished the level. This allowed a really easy and straightforward evaluation of player performance during each study. We had two main ways of measuring players performance: lap time and total distance. Our primary measure was lap time, which was the average amount of time in each gameplay session it took to complete each repeat of the level. This, however, required us to remove the players' last lap before the break, as it would get cutoff and be incomplete. To capture this data, we had a secondary measure, total distance, which was how far a player went before time ran out in each segment. We also had other measures such as pitfalls, average times for sections of the level, and tracking of player locations. This method of evaluation was the same in Study 1 and Study 2.

We determined if players were improving over time by comparing their average lap time and total distance across their four gameplay segments. We displayed these averages in a line chart, analyzed whether players showed a traditional learning curve in both lap time and total distance. We also tracked their positions to place on a heat map, to see how their routes changed across their four gameplay segments.

For Study 2, while measuring performance was the same, we needed to also evaluate if players were engaging with their breaks to determine if there was an effect of activities on breaks. We did this by recording player inputs in all breaks, and specifically counted the space bar presses, as it was the primary method of interaction for all breaks. Other required button presses and mouse movements in the breaks were also recorded, to ensure the player was actually progressing through the break levels.

To evaluate player skill, achievement orientation and overall desire to win, we had them answer questionnaires about their experience with games, platformers, achievement, and win orientation. To evaluate player engagement and flow, we had questionnaires for the player after they had completed all four segments of the platformer.

1.5 Contribution

This thesis makes three main contributions to the understanding of how spaced practice and breaks affect player performance in video games. There is very little research into the spaced practice effect in video games and the research that does exist uses very simple games [46, 57]. While this previous research does provide some evidence, the authors used games that involve one or two buttons and have very simple objectives, which makes the results not easily applicable to other games. Our first contribution shows that spaced practice significantly improves learning and skill development in a 2D platformer, a relatively complex game involving multiple skills. While this game is not as complex as a FPS or RPG, it is more complex than games used in prior research and adds significant evidence that spaced practice is effective in games. Therefore, designers can make use of this principle in a wider variety of games with confidence that it is having its intended effect.

The second major contribution is that spaced practice is effective across several types of ecologically valid break activities varying in intensity and similarity to the game task. Designers have substantial freedom to create break activities that suit their game, without losing the benefits of spaced practice. This means that designers can have breaks that make sense with their game while also giving players predictable and consistent performance benefits. Games already have a wide variety of activities or variations of the main gameplay task to ensure the player does not get bored [52]. However, these other activities can often become annoying or distracting if not implemented properly, becoming detrimental to the player experience [52]. By being able to implement different gameplay activities as breaks for spaced practice, activities can be designed with that purpose in mind.

The final major contribution is that we show that the use of short breaks does not interfere with flow states or negatively affect player experience. A major concern with spaced practice is that while it could have a positive effect on player performance, the consistent and predictable starting and stopping may cause players to disengage. This would be bad, as good games are meant to keep players engaged, and if spaced practice negatively influenced engagement, then the performance benefits would have a serious trade off. However this is not the case, as we found players felt engaged with our game despite the breaks. This means that designers can make use of spaced practice without fear of undermining flow and there is some evidence that it does not influence the experience negatively.

This work was published in a peer-reviewed article, as the following citation: *Piller, B., Johanson, C., Phillips, C., Gutwin, C., and Mandryk, R. L. (2020, November). Is a change as good as a rest? Comparing breaktypes for spaced practice in a platformer game. In Proceedings of the Annual Symposium on Computer-Human Interaction in Play (CHI PLAY), pg. 294-305.* As a co-authored paper, multiple authors contributed to the work. I led the work, designed the game, implemented the game, gathered the data, analysed the data, and wrote and edited the paper. The other authors were involved throughout the entire process, providing input on the game design, experiment design, data analyses, and contributing to writing and editing. In addition, C. Johanson conducted data analysis and generated figures.

1.6 Thesis Outline

Chapter 2 provides a literature review on related human computer interaction and games research. This starts with an overview of spaced practice outside of video games, then goes into the effects of spaced practice on video game player performance in both lab experiments and analysis of gameplay in commercial games. We then discuss the theory behind skill development and how spaced practice helps with skill development. We briefly discuss how task switching literature can provide insight into how switching between tasks may influence skill development. Then we discuss skill acquisition in video games, tasks players could perform during breaks, and how current commercial games use breaks tasks.

Chapter 3 describes the motivation behind the questions we ask about spaced practice in games, as well as the methods we used to to evaluate player skill progression and their experience when using spaced practice. This starts with a description of our aims and motivation with this work, resulting in our three research questions we want to answer. We then discuss the measures and constructs we used to evaluate player performance and experience. We then give a brief overview of each study and how the differences between the them. Finally we give an overview of the system we designed for our studies, and the factors that went into designing them.

Chapter 4 describes in detail the process of Study 1. This starts with a more detailed description of Study 1, including our implementation of spaced practice within our game. We then discuss the procedure of running the study and the recruitment of participants. After that we present the analysis and results of the study, and finish the chapter with a summary of the results.

Chapter 5 then presents Study 2—a study done using the same system as Study 1, but with modified breaks. In this study, the breaks between each main gameplay task have an activity for the participant to do based on related work in Chapter 2. We start the chapter by discussing the process of developing breaks for our game and how this factored into the design of the study. We then discuss the procedure, recruitment, analysis and results as we did in Chapter 4.

Chapter 6 discusses the explanation of the effectiveness of space practice in relation to our three research questions outlined in Chapter 3. Then it discusses implications of our findings on commercial games, game designer, player skill, player experience and research into skill progression in games. Finally we consider the limitations of our two studies and potential future work.

Chapter 7 concludes this thesis with a summary of our findings and an overview of our contributions: 1) spaced practice works in complex games, 2) break activities during spaced practice do not alter the benefits of spaced practice, and 3) breaks and break activities do not interrupt player flow states.

2 Related Work

2.1 Spaced Practice

There are numerous skills players use when playing games, often varying and changing depending on the game. Games require players to use physical skills, such as hand eye coordination when using a controller or physical stress tests with button presses. In some instances with motion controls, players are required to move parts of, or all of, their body. Then there are mental skills, where players need to use different mental faculties in order to succeed, such as memorization, strategizing, and problem solving. In games that involve other human players, social skills such as communication and cooperation are often required in order to succeed at the game.

Often game designers create games that focus on players using these skills, but not to develop these skills, at least not intentionally. Usually game designers focus on making the game as fun or entertaining as possible, with interesting mechanics that keep players coming back. In *Borderlands 2* [41], the key focus of the design was not to have players engage in critical thinking, yet is a core skill when the player decides what weapons they want to use [55]. *Left 4 Dead* [93] was designed to enforce cooperation between players, but does not require players to improve their skills throughout the game [55]. Skill development is important for player experience, as acquisition of skill is tied to positive player experiences. Designers already know that having players use these skills leads to better enjoyment, but designing a game that facilitates the player skill growth could make even better games.

A theory of skill development that is widely studied is spaced practice. Spaced practice (or distributed practice) refers to scheduled periods of breaks in between periods of activity or work during a training session [76]. Spaced practice is often contrasted with continuous practice [76]. Continuous practice refers to running activity or work periods close together with no rest or very brief rest intervals [76]. There is often no fixed timing for rest periods relative to work periods and any amount of rest compared to continuous practice is usually considered spaced practice. It is often found that the longer the rest period in spaced practice, the better the performance gains.

There is considerable evidence to support the effectiveness of spaced practice in skill development, in tasks ranging from learning lists of nonsense syllables [32], tracing objects through a mirror [82], typing [11], and fear desensitization [69].This is often attributed to continuous practice causing greater muscular fatigue when compared to spaced practice. However, this degradation due to temporary fatigue cannot be the only reason for differences in performance, as performance loss due to fatigue does still occur in spaced practice [96]. How much of the difference between continuous practice and spaced practice is due to fatigue versus learning the skills during the task? Often during spaced practice experiments, retention tasks are included in order to determine how much of the task is actually being learned and how much of the performance gains are temporary [15]. With a retention task, it is found that those who do spaced practice perform better after a long rest period than those who just did continuous practice tasks. This is attributed to during continuous practice the brain is given no time to generalize feedback from the task, whereas during spaced practice the brain is given time to process and apply feedback from the task [24, 84].

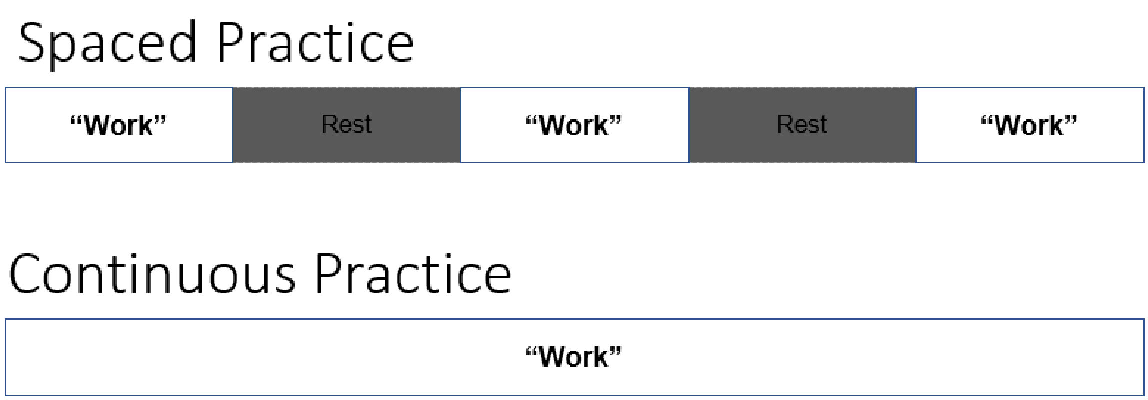

Figure 2.1: Visualization of Spaced Practice vs Continuous Practice

Meta-reviews of spaced practice studies show that it has a strong effect [50, 28]; however, these reviews do not necessarily provide unequivocal support for the idea that space practice enhances learning compared to continuous practice. Task related factors can impact the effectiveness for spaced practice. For example, some studies suggest that more complex tasks appear to benefit less from spaced practice [28] – such as learning a musical sequence on the piano [101] or learning specific math problems [61]. Overall it appears spaced practice is more effective for simple motor tasks rather than complex tasks [28]. The effectiveness of spaced practice is also influenced by the individual's skill level in the task. There have been studies that show spacing is most effective early on [82], with continuous practice becoming better in the later stages of practice [49].

2.1.1 Research on Spaced Practice in Games

Most research on spaced practice in games has focused on serious games in the context of education and verbal learning (e.g., [33, 74, 75]). The few studies that do focus on in-game skills support the idea that spaced practice has benefits [57, 46, 80, 45].

The earliest study from 1985 [57] had participants play the Apple II+ game *Little Brick-Out*, a *Breakout*-inspired single player game where players control a paddle to hit on-screen bricks with a bouncing ball. The experiment had the player play 10 rounds of gameplay with each round lasting between 57 to 232 seconds. In-between each round, players were either given no break or a 2 minute break where the participants were instructed to read a newspaper. The study found that spaced practice resulted in better performance at the 10th training session over continuous practice. However, there are a number of design choices in the study that present issues. First there was no retention test performed after this study, so there is no indication if the gains from spaced practice would be lasting. Second, the spaced practice group had higher initial performance than the continuous practice group, having an advantage over the continuous practice group. Lastly, the game's rounds lasted longer the better a player performed. This meant that the spaced practice group trained for 27 minutes, while the continuous practice group trained for 15 minutes.

Another study from 1999 had participants play a game called *Space Fortress* [27], a more complex variation on *Asteroids* [10] with additional strategic elements not focusing on perceptual motor tasks primarily. The experiment had participants play the game for 10 hours, spread over either 2 days or 10 days [80], with a retention task one week after the last day of training. Results showed that participants who trained over 10 days outperformed participants who trained over 2 days at both the end of training and during the retention test. One major issue with this study is that it involved substantial coaching of the participants. Participants were able to watch videotaped instructions and were often encouraged to try different strategies or use other strategies players found effective.

A more recent study from 2019 provides further evidence that spaced practice works in video games and had some findings about optimal break lengths [46]. Participants played a clone of *Super Hexagon* [19], in which they control a triangle that can rotate around a central hexagon, using the arrow keys on a keyboard to move left or right. In each of the 6 regions of the hexagon, obstacles will appear outside of the screen and move inward towards the center. Players must move to an open region to avoid being hit by the obstacles. The player's goal is to stay alive as long as possible, with the game getting progressively harder, by increasing the camera rotation speed and rate of obstacle spawn and move. Participants played the game for a total of 25 minutes divided into four five-minute sessions. In between the sessions was one of five break interval groups: a continuous practice group with a rest interval of 3 seconds—and four spaced practice groups with break intervals of 2 minutes, 5 minutes, 10 minutes, or 1 day. Participants in the spaced practice group were instructed to use their computer in any way they wanted during breaks to simulate what would happen in the "in the wild". To evaluate participant learning, participants were invited back for a 5-minute retention task one day after the final training session.

This study found that the continuous practice group performed significantly worse than every spaced practice group except for the 1 day group. These two groups caught up to the performance of the other groups during the retention task. This indicates that spaced practice was more effective in immediate performance, but was relatively weaker in long term performance. In analysing the data for the optimal break length, they also found that the gains in the 10-minute group initially were larger but decreased over time and their retention performance was not significantly better than other groups. The 2-minute interval was their other candidate for optimal break length, having shown more consistent improvement throughout and with players having rated their enjoyment higher. Of these three studies, only one put constraints on what participants were to do with their break.

Another recent study from 2017, while not looking at spaced practice explicitly, had findings relating to breaks and the acquisition of spaced practice in two commercial games [45]. Huang et al. analyzed player data in the first person shooter *Halo Reach* [17] by looking at how players' skill progressed, rated by the TrueSkill system (a skill based ranking system developed by *Microsoft*), over the course of a seven month period. The TrueSkill system is a player skill rating system used in numerous Xbox titles, that evaluates player skill in order to ensure fair matchmaking. The authors retrieved 3.2 million players' TrueSkill ratings from the official Halo servers. When analyzing the data they found that players who spaced out their practices over longer periods of time, playing 4 to 8 matches a week, progressed in skill more efficiently, aligning with the current research on spaced practice. However, those that played more than 8 matches a week, despite learning at a lower rate, were able to improve the quickest over time. They found that when players took breaks over the course of days, there was a recovery time when they returned to the game. The longer the break, the longer it took players to regain their skill level from before taking the break. Their overall findings indicated that when players played more frequently they were prevented from earning skills optimally, but taking too long of a break resulted in a loss of skill. Play should be consistent and sustained, while incorporating breaks that do not have too wide of a time interval. Their findings suggest that while the benefits of spaced practice do exist in commercial games, there are limitations to the effectiveness and how players can use it effectively.

While these studies do provide evidence of spaced practice being effective in video games, there are limitations to these studies. First, the three structured experiments used very simple games. Two involved very simple mechanics and goals [57, 46]; while the study by Shebilske et al. [80] involved additional strategic mechanics, the mechanics and goals overall were still fairly simple. Second, only one study [80] restricted what players did during their breaks; however, this was out of the digital world using a physical world object. These results are not very transferable to games that have more than a few mechanics and controls and provide little guidance on break design beyond some findings of an optimal break length.

2.2 Skill Development

In terms of *why* spaced practice works, there are several factors that could be the reason. Performance improvements are largely due to decreases in reaction time, improvements in selecting responses to stimuli, and reduced errors in execution [67, 89, 76]. Progress in performance is described in terms of the learner transitioning [85] from early stages of skill development to later stages [35, 49]. This follows a predictable pattern, described as the power law of practice [82, 65, 76, 89]. Skill improves as a function of the number of repetitions, with dramatic improvements at the start and eventually slowing down towards the end.

There are three major stages of skill development: cognitive, associative, and autonomous [76, 35, 67, 66, 49]. The first stage, the cognitive (or declarative) stage is when skill development has initial poor performance with many errors, but the most gains in improvement [65, 76, 49, 35, 67, 66]. Forgetting through lack of use in this stage is prevalent [21, 77], so learners must give their full attention to the task. At the end of the cognitive stage, learners start to form stimulus response codings and the procedural knowledge they will use in the next stages [67, 49, 99].

The next stage is the associative (or mixed) stage, where there will be a significant reduction in errors, greatly improved performance but slower performance gains. The learner develops a consistent response pattern, their ability to identify relevant stimuli improves and they can leverage procedural knowledge over declarative knowledge [35, 89, 49] (see section 2.2.1).

The final stage is the autonomous (or procedural) stage, characterized by few errors, stable performance with little improvement [49, 76, 65]. The learner is able to perform the skill with little error and responds to stimuli automatically [89]. However, continuing to improve at this stage is very difficult.

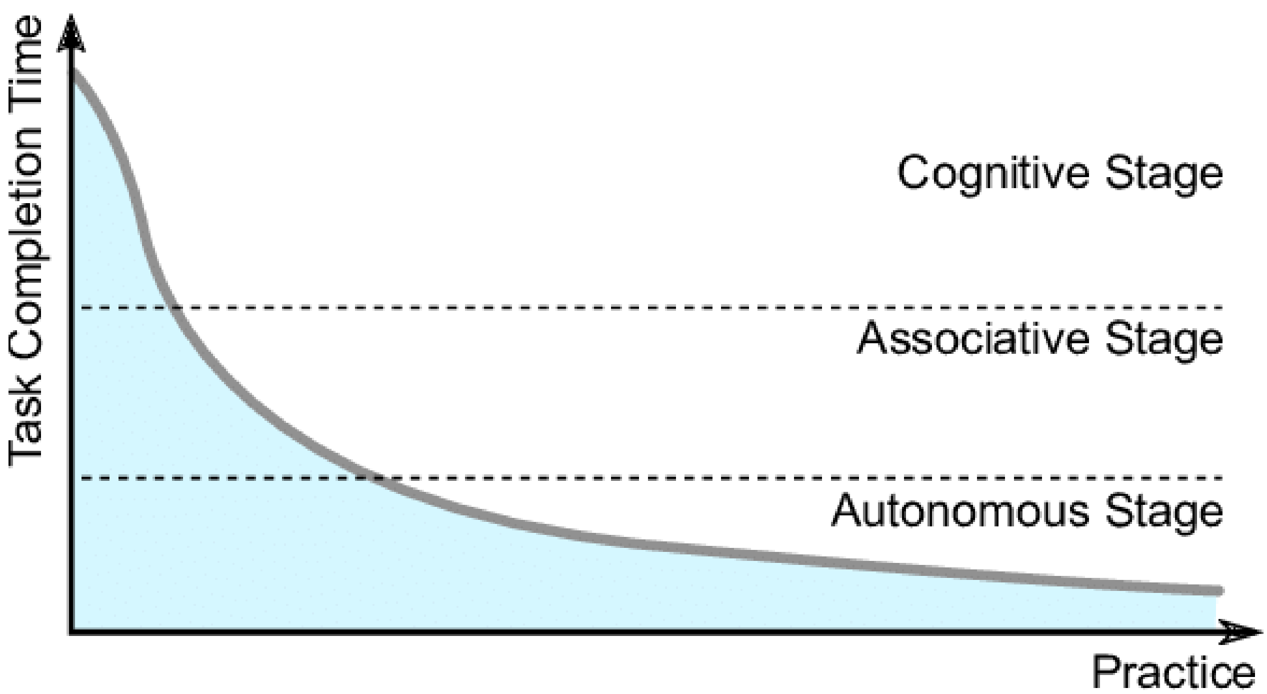

Figure 2.2: Figure 1: The three stages of learning approximately mapped to the power law of practice. Adapted from [49]

2.2.1 Why Spaced Practice Helps in Skill Development

Spaced practice has been shown to assist the process of skill development [86], in part by supporting knowledge compilation, a gradual process whereby declarative knowledge (verbal information about a skill) becomes encoded as procedural knowledge (a set of procedures that can be applied directly in the execution of a task) [7]. Similarly, in terms of motor memory, spaced practice is thought to assist in a consolidation process in which memories become more stable and resistant to decay [24, 84]. Additionally, spaced practice can reinforce memory retrieval better than continuous practice. During continuous practice, memories traces from preceding trials are still active, and therefore do not need to be retrieved and do not create stronger memories. By taking a break from a task, this forces retrieval and reactivation of the relevant memory traces when returning to the task, reinforcing them [96, 71]. Another possible reason for this is that breaks change the context of the traces. Having more contexts leads to easier retrieval of information [96]. It is also suggested that the length of breaks during spaced practice can influence the retrieval of memory traces. The longer the interval between each task, the stronger the memory of the learned skill is, reducing interference during the subsequent tasks [96].

Spaced practice may also work because of fatigue effects. It was once thought that benefits were driven by muscular fatigue [6, 31]; however, retention tests provided after a break showed that improvements often persisted (e.g., [15]). Fatigue is often not solely responsible for the differences between spaced practice and continuous practice. Psychological factors such as decreased attention or effort from boredom can influence performance and learning [96]. This is also known as cognitive fatigue, where participants may not be able to give the task their complete attention for the entirety of the study [96, 4] and this decreased attention can negatively affect performance and learning. What can happen during massed practice is the participant's mind can wander after doing the task for some time [58]. Participants may feel that after doing a task for a long enough time that they have learned enough about the task and their minds begin to wander. This causes them to disengage with the task and start to perform worse in the task, creating a negative feedback loop of perceived lack of learning, which leads to mind wandering, which leads to more lack of learning [58]. In spaced practice, the amount of time spent with a task constantly is less, making the person feel like they have not done the task long enough, reducing the chances of mind wandering and keeping them engaged with the task. Despite these other factors, fatigue can still play a role [96].

2.3 Task Switching

Research on spaced practice provides some information on whether breaks help performance in video games, it however provides little guidance on what players should do during breaks. Players often do not want to take breaks [96], and would likely become frustrated by being forced to take breaks. However if we were able to implement breaks in a way that they were hidden or had some way of engaging the player, then this would make spaced practice much more viable an option for improving player performance in game. This would only work if switching tasks could first, be beneficial for performance itself, and second, not hinder the benefits of spaced practice. We do know a lot about task switching as a whole, which may give some insight into how doing tasks during breaks may impact spaced practice.

Task switching is a paradigm that interleaves simple tasks together and performance is disrupted when a switch from one task to another is required [8]. Task switching can also be viewed as a trait, with individual differences being described in terms of cognitive flexibility, i.e., the ability or readiness a person has to change in response to environmental stimuli [78]. There are several factors that influence how much task switching impacts performance and learning.

The first factor is called switch cost, which is how much the performance degrades relative to familiarity of the task. Switching from a familiar to unfamiliar task has a greater cost than switching from an unfamiliar to a familiar task [72]. Even though immediate performance may decrease, learning may improve, as determined by performance on retention and transfer tests. If the task that is being switched to relies on similar skills, this added variability of practice results in increased generalizability, and the learner can better apply the new skill to novel or changing environments [76]. The second factor, called the preparation effect, can be used to reduce the cost of a switch. By giving the person advance knowledge of the upcoming task and time to prepare, the average switch cost can be reduced [60]. The third factor is residual cost, which is when the reduced cost is not entirely eliminated from preparation. The final factor is mixing cost, where responses remain slower than when one task must be performed throughout the block, even though performance recovers rapidly after a switch.

There are studies that indicate switching between certain tasks can have detrimental effects on performance. One study by Rubinstein et al. [72] tested participants' task switching ability by having them classify shapes and solve arithmetic problems. Some groups were given problems that repeated, while other groups were given alternating problem types. The study found that the alternating groups had more errors, that increased rule complexity led to a greater number of participant errors, and that switching from familiar to unfamiliar tasks had a greater cost than going from an unfamiliar to a familiar task. However, other studies have shown that while variable tasks lead to detrimental performance, transfer and retention tasks improve [76]. One study (see [76]) had participants knock over a barrier at varying distances over 300 trials. There were four groups of consistent distances and one group that had the distances vary over the trials. Each group then performed a transfer test phase immediately after the first task and 48 hours later, with all groups performing at the same distance. During the original practice, the constant groups had fewer errors, but during the immediate transfer phase, the variable group performed better. During the delayed transfer, the variable group still performed better but to a lesser degree.

2.3.1 Task Switching in Video Games

There have been several studies on the task switching abilities of video game players. One study by Colzato et al. [22] had two groups of participants, one group with primarily first person shooter (FPS) video game experience and one with little to no video game experience, perform a simple task where participants had to press the correct button depending on stimuli on screen. They found that the video game group showed smaller switch costs than the non video game group, indicating better task switching ability. This aligns with another study, where researchers had action video games players and non video game players pressing arrow keys in familiar and novel tasks [18]. They had similar results, where the video game players showed less switch costs between tasks. While these studies do not provide evidence that switching between tasks improved player performance, they do provide evidence that video game players are able to switch between tasks with less detrimental effects. This means that if breaks in spaced practice had a task for video game players to do, they will likely be able to switch between tasks with minimal switch cost, preserving the performance gains from the breaks.

2.4 Skills in Video Games

Skill acquisition is a seemingly ubiquitous concept in video game design, with the majority of games requiring players to develop their in-game skills as gameplay progresses. Players' skill development gives rise to both functional and psychosocial consequences [3]. In functional terms, the player's ease of control increases, and they become more capable of meeting the game's challenges [68, 73]. In psychosocial terms, players have increased subjective feelings of competence or mastery [68]. While these psychosocial benefits are important for facilitating positive player experiences, the effects of skill acquisition on challenge has interesting implications; challenge-skill balance has been the subject of extensive investigation, primarily because it is generally considered to be an antecedent to flow states [63, 36].

Flow is an 'optimal experience' associated with task enjoyment [81]. Flow states are intrinsically rewarding and autotelic experiences characterized by intense focus and concentration, the merging of action and awareness, a loss of reflective self-consciousness, a sense of agency, and an altered sense of time perception [63]. Flow theory has been broadly applied in the context of digital games, and many commercially successful games are considered to promote flow states [38]. Because flow is associated with positive player experiences, many game designers seek to create experiences that promote flow states.

There are generally three antecedents to flow: clear goals, clear and immediate feedback, and a sense of balance between perceived challenge and perceived skills [63, 36]. Adding clear goals, immediate feedback [88], and increasing a game's challenge [42, 87, 100, 48] are straightforward ways that developers build with flow in mind; however, developers have limited control over skill acquisition. To facilitate skill acquisition, game designers employ in-game tutorials, and laboriously playtest and craft difficulty curves so that the average player's skill increases as the game progresses. However, adjusting the level of challenge does not account for individual differences in skill development. Some developers incorporate dynamic difficulty adjustment mechanics, which adjust the game's challenge on-the-fly, so that it is better matched with the relative skill of the player [103].

2.5 A Design Framework for In-Game Breaks

Aside from the suggestion that the breaks need to be more 'restful' than the task [76], the literature on spaced practice provides little guidance on what participants should do during breaks. Therefore, we look to the design of commercial games for inspiration. For our studies, we wanted our game to focus on action and performance. Our design is meant to encompass games that require fast reflexes and timing, while other games that require different kinds of attention may not fit into our framework. We differentiated the breaks based on two types of fatigue: mental and physical. Physical fatigue possibly resulting from repetitive button presses and movements, and mental fatigue possibly resulting from repeatedly doing the same tasks. If physical fatigue is the main factor for breaks being effective, then breaks with less interaction may be more beneficial. Conversely, if mental fatigue is more affected by breaks, then changing to a different task regardless of interaction level could be more helpful. This leads to breaks being categorized in terms of two dimensions: *intensity* (physical fatigue) and *similarity* (mental fatigue).

2.5.1 Breaks in Commercial Games

In looking to design breaks, we need to look for possible examples of breaks in commercial games. We discuss how commercial games design and implement breaks. We analyze and compare different breaks based on two axes—similarity and intensity—and use this to inform our break design. Short periods that interrupt core gameplay are common to many games. Commercial games often include a variety of tasks, which may or may not serve as a rest, but do act as a 'break' by using mechanics that differ from the game's core mechanics [5].

There are many examples of breaks in commercial games and they are used in a variety of ways. One group of breaks is breaks that require minimal to no player interaction and are not part of gameplay. This includes breaks such as cut scenes, loading screens and waiting to respawn. These breaks can be easier to set up as they do not need to integrate with gameplay directly and usually happen at the developer' or designer's discretion. They may occur due to hardware limitations, such as a loading screen, or due to player progression. These breaks could be considered more restful and act as an ordinary break would for the player. Another group of breaks similar to the prior group is menus, such as pause menus, start screens, and inventory screens. This is similar to loading screens and cut scenes because menus are usually not directly integrated into the main gameplay of the video game. However the major difference is that menus require the player to interact and often must start the break through their own actions directly. While it could be argued these are not breaks due to them not being a complete rest, they are distinctly different from the main gameplay usually and have a lot less stimulus.

Alternatively if we consider breaks as more a change from doing the same task over and over, breaks can also be directly integrated into gameplay. A number of these types of breaks already exist in video games, such as minigames, boss battles, and walking segments. Breaks such as minigames often require a separate screen or shift in perspective to interact, such as the hacking minigames in *Fallout 3* [14] or the card game Gwent in the *The Witcher 3* [20]. These are usually entirely different in terms of gameplay and can be more or less intense than the main gameplay loop of the game. While this once again is not a "rest", it is a change that could be beneficial for the player to break up the monotony and keep them engaged with the game. Breaks could also happen within gameplay, as the gameplay shifts from segments that require more or less skill from the player. Walking segments, such as in *The Last of Us* [64], provide a much needed break in both the story and gameplay, giving players a chance to understand what is happening during the level and giving their mental and physical faculties a rest. Boss battles could be considered a break or change that requires players to apply all the skills they have been learning in the game in a different way or under more pressure than before. Once again not being a rest in the traditional sense, the shift in intensity from the regular gameplay should grab the players attention and force them to use skills they have been learning more effectively.

In-game breaks present themselves in many different ways, but for our purposes we needed a way to describe break commonalities and differences

2.5.2 Similarity

The first set of criteria we chose to compare different in game breaks is similarity. Based on research in task switching, switching to a similar task should result in better performance [8]. This would lead to an assumption that gameplay tasks that are more similar to the main gameplay loop would make for better breaks in spaced practice. However, if the task is too similar to the main gameplay, it could nullify spaced practice and become continuous practice. Additionally, not all games are going to want to use breaks that are similar to the main gameplay loop, so it is necessary to understand where the limits of similar and dissimilar are when making breaks.

In-game breaks vary in terms of their *similarity* to the core game mechanics. For example, a common break in commercial games is the use of a cut-scene or dialogue interaction. These breaks often come at the end of a level or after finishing a significant game segment, as a small reward for the player [39]. *Half-Life* [91] famously used this technique to break up levels with dialogue between in-game characters. In these breaks, players' interactions were similar to the main game. Players would remain in the same first person perspective, and they could walk around and interact with the game world as they normally would. The game would often prevent players from proceeding with the level until the dialogue is done, giving the players no choice other than to engage with the dialog.

Not all games will work with a passive break, so giving players breaks that engage them through gameplay may work better in some instances. Additionally giving the player agency in the decision on when they take their breaks through gameplay mechanics could help reduce frustration [53, 62, 47]. Mini-games are another common break type to add variety to gameplay, and can vary widely in terms of their similarity to the main game. In *Bioshock* [2], players switch from a first-person shooter to a hacking mini-game, where tubes must be aligned to create a path for fluid. This mini-game is substantially different from the main shooting mechanic of the game and requires a different set of skills giving the player some variety in the gameplay. Unlike *Half Life*, the player has agency on when and where they engaged in the hacking minigame. The breaks are administered based on the player's discretion and the breaks have a maximum length, though player skill can shorten the length.

Another example of a break that has low similarity is the first-person shooter *Counter-Strike* [92]. When players die during a match, they are made to watch until the round is over. This break is a much more explicit rest than the examples above—dead players can only watch the game until the round ends. This gives players a physical rest by severely restricting the available interactions. Because players are presumably interested in the outcome of the round, however, they remain engaged with the game while resting. They can also observe other players in order to reframe how they may want to adapt their play style.

2.5.3 Intensity

Similarity did not encompass the full scope of breaks in games by itself. While categorizing breaks based on how similar or dissimilar a task is does address the range of types of activities, it does not address if a break actually has to be restful, and we identified multiple components related to this question. First is the relative complexity of a break compared to the main gameplay task. Does a break have to be simpler than the main game? Can a break involve more mechanics and require more problem solving than the main game? The next major component is difficulty of task. Can a task be more difficult than the main gameplay loop while still giving a break? And finally, can a break have more perceived pressure than the main gameplay task? While all of these individually provide interesting insights, for the purposes of this study we needed a way to categorize them together as individually they did not encompass a wide enough range. This led to us using them as factors in intensity, or how much stimulus a break induces and how much interaction is required.

Considering the examples from the previous section, cut-scenes, dialog, and waiting to respawn in *Counter-Strike* are all examples of the game shifting towards less intensity. However, breaks in games do not necessarily have to be separate screens or entirely different from the main gameplay. Independent of whether the task is similar to the core game, breaks can also vary in the *intensity* of their activity's mechanics. In-game breaks can occur, where within the context of the main gameplay mechanics players are doing something that is not the main loop or vice versa, where the main mechanic may facilitate a break from another task in game. Break activities typically reduce intensity. For example, when players are defeated by a boss in *Dark Souls* [37], they respawn at a previously visited bonfire and must walk back to the boss while facing respawned enemies. Forcing the player to travel takes time, providing a chance to reconsider tactics. In contrast, other games respawn a player at the beginning of the fight, returning them to action immediately.

There are also cases where intensity shifts to be higher than normal. These may not provide the player a rest in the traditional sense, but they do serve to capture a player's attention and break up any monotony in the game. For example, in *Left 4 Dead* [93], players spend most of their time in levels searching for supplies and routinely shooting zombies as they try to survive until the end of the level. Randomly and infrequently, the game will spawn boss zombies that requires coordination and communication from all players to be defeated. These events provide players a

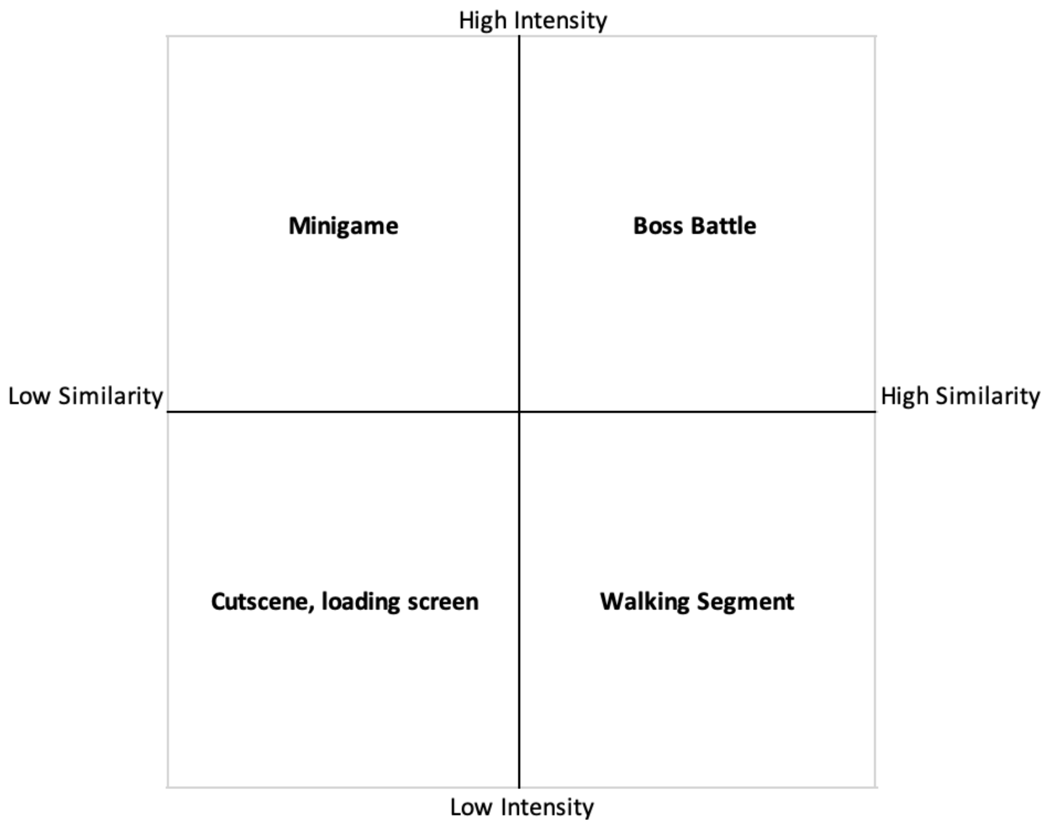

Figure 2.3: Chart shows examples of breaks from commercial games on a high and low similarity vs intensity axis

brief but intense moment of gameplay that is a break from the usual gameplay loop. Boss battles serve a similar purpose. While these could not be considered *rests*, they are shifts that give a break from regular gameplay. This allows players to apply their skills in new ways or potentially learn new skills. Mini-games can also provide shifts in intensity as well. Mini-games may or may not be as intense as the main game. For example, in *Donkey Kong Country* [70], the mini-games use very similar mechanics to the rest of the game, and have a timer counting down, resulting in a level of intensity that is the same or slightly greater than the core gameplay.

2.5.4 Literature Limitations

Game designers create games focusing on player skill, but do not necessarily facilitate skill development. One method designers could use to facilitate player skill development is spaced practice, which has been shown to assist in skill gains in various other activities [32, 82, 11, 69]. There have also been studies about the effects of spaced practice in both commercial games and laboratory experiments [57, 80, 46, 45]. There is a gap in the literature due to the lack of variety in games used in these studies. Most of the games used were simple, requiring basic skills to complete the games. While spaced practice may work well in these games with one or two mechanics, there is not certainty that spaced practice would work when there are multiple mechanics that the player must use constantly. The one study that does use a commercial game with various mechanics [45] observes spaced practice between gameplay sessions, rather than within gameplay sessions. So while there is evidence that spaced practice works in complex games in between play sessions, there is no evidence that spaced practice works during a play session in complex games.

Another gap in these studies is using breaks that do not require the player to do anything. Only one study restricted what the player did in the real world [80], but none restricted the player in game. There is no information on what the player should do during a break or how switching between tasks could influence the player's performance. There are studies where switching between certain tasks can have detrimental effects on performance in that task [72]. This is important for designers to understand, because players will likely not want to take breaks, especially if they have nothing to do during those breaks. Designers will likely need to implement some form of a break activity, but if this activity has detrimental effects on player performance to the point where the gains from spaced practice are negated, it may not be worth using spaced practice.

The final gap in prior research is lack of consideration for the player experience and how player flow is affected by breaks. Flow is important for players, as it is intrinsically rewarding and promotes a positive experience [81]. Designers want to create games that promote flow, which can be created through a balance of challenge and player skill [38]. Since spaced practice in games has been shown to increase player skill, it could be assumed it promotes flow states. However, the start and stop nature of taking breaks could have a major effect on flow. Related to the previous gap, different activities during breaks could affect the player experience differently and therefore create different flow experiences. Prior research has mostly ignored how breaks affected the player experience and flow despite its importance to games.

3 Methodology

3.1 Research Aims and Motivation

This research seeks to understand the effect breaks in video games have on player performance and experience. As noted in the related work (section 2.5.4), the study of breaks and spaced practice in games is limited, focusing on how breaks affect the player performance. While these studies provide evidence for the effectiveness of spaced practice over continuous practice in games, they do not provide any insight into how spaced practice should be implemented into games or if spaced practice works in all games. The video games used are relatively simple and do not address the potential limitations of using spaced practice in larger more complex commercial games. Additionally, there is no study on how breaks affect the player's experience. There is no insight into how what the player is doing during the break might affect the performance gains, or if the player should be doing anything. The research is very limited when it comes to determining if breaks make for a good gameplay experience, maintain flow, or if players even like taking breaks. This research aims to build upon prior work, addressing gaps in knowledge by answering three research questions.

3.2 Research Questions

Does Spaced Practice Work in a More Complex Game?

As mentioned in section 2.1.1, research into spaced practice in games has used relatively straightforward games, with simple mechanics and objectives. Only one study observed the effects of spaced practice in a commercial games [45]; however, it was only used to explain why players were getting better between gameplay sessions rather than within a gameplay session. If games designers are going to use spaced practice, there needs to be evidence that spaced practice works in a game with more complex mechanics and objectives, to ensure the use of breaks is applicable to a wide range of games.

Does the Type of Break Activity Affect Player Performance?

This is the main focus of this work; to determine if doing activities during a break does not interfere with the gains made by spaced practice, and if there are differences between break activities. The section 2.5.4 notes that all but one study do not have the player do anything in game while they are on their break. The one study that did had players reading a newspaper, an activity not part of the game [80]. It is likely outside of a research setting players will not want to take breaks, especially when in a state of flow. This presents a problem where designers want players to take breaks, but do not want them to quit playing. If games can implement breaks using the various activities that already exist in games outside of the main gameplay loop (e.g., loading screens, menus) without negating the benefits of spaced practice, this could provide designers with a powerful design tool to use in their games.

Do Breaks and Different Break Activities Interrupt Flow?

Finally, flow states are a positive player experience—and are typically associated with intense focus and immediate feedback. It is unclear whether or not breaks will affect flow states—a positive experience typically associated with intense focus and immediate feedback. On the one hand, switching to a break activity may interrupt focus from the primary task, undermining flow in the process. On the other hand, a break may be perceived as another part of gameplay, such that it will not interfere with flow. It is important to determine whether or not flow states can be undermined by spaced practice, as many game designers intentionally design for flow states.

3.3 Constructs and Measures

3.3.1 Player Performance

Attentional Control is a construct that describes a person's ability to concentrate and explicitly direct their attention. Attentional control is relevant to this work because players with greater attentional control may perform better—influencing performance measures related to spaced practice. We measure attentional control using the Attentional Control Scale (ACS) [26]

The Attentional Control Scale (ACS) [26] is a measure of attentional control (i.e., their ability to concentrate and explicitly direct attention). The ACS is a 20-item self rating scale, with responses being scored on a 4-point likert scale that ranges from 1 (almost never) to 4 (always). Some example items include: "It's very hard for me to concentrate on a difficult task when there are noises around", "When concentrating I ignore feelings of hunger or thirst" and "It is easy for me to alternate between two different tasks".

Achievement Orientation is a measure of participant competitiveness (i.e., overall desire to meet a standard of excellence or compare favourably to competitors), win orientation (i.e., importance of outperforming the competition), and goal orientation (i.e., importance of achieving specific performance goals). Achievement orientation is relevant to this work, because highly motivated players may put more effort into improving at the game. We measure achievement orientation using the Sport Orientation Questionnaire [43] (SOQ).

The SOQ was developed as a multidimensional tool, sport specific measure of individual differences in sport achievement orientation. The SOQ is a 25-item self rating scale, with responses being scored on a 5-point likert scale that ranges from 1 (strongly disagree) to 4 (strongly disagree). Some example items from the questionnaire include: "Winning is important", "I try my hardest to win", and "I try my hardest when I have a specific goal".

Gaming Expertise is a measure of participant video game play experience. Gaming expertise is relevant to this work because players who like games or play games frequently may improve differently than those who do not.

To measure prior experience with gaming, we designed an item with two 100-point sliders: "How much do you self-identify as a gamer?" (1="not a gamer" 100="gamer")" and "How familiar are you with side-scrolling platform games?".

Average Lap Time. For each gameplay segment, the number of times a player completed the level (laps) was counted. Within each gameplay segment, we calculated the average lap time for each player, excluding uncompleted laps.

Distance Travelled. For each 5-minute gameplay segment, the distance between the start and where each player stopped when time ran out was measured. This measurement did not include backtracking or the distance of failed attempts. Unlike lap time, this measure incorporated laps that were uncompleted when the timer expired.

3.3.2 Player Experience

Flow is a positive state that involves an individual entering a state of 1) merged action and awareness, 2)challenge skill balance, 3) unambiguous feedback, 4) concentration of the task at hand, 5) time transformation and 6) fluency of action [97]. This is relevant to our work because many games are designed to invoke flow, and it is related to both player experience and performance. Several of flow's antecedents may also be impaired by intentional breaks in players' focus, so we sought to explore this in depth.

To measure flow, we used the Flow Short Scale (FKS) [97]. The FKS was selected due to its relative focus on performance oriented subconstructs of skill; fluency of performance, demand, and fit of demands and skills [97]. In addition to these four subconstructs, the FKS also measures absorption by activity, which was included in the design due to its relevance to break types, and its broader implications for flow states. The FKS is a 10-item self rating scale, with responses being scored on a 7-point likert scale that ranges from 1 (not at all) to 7 (very much). Some example items include: "I feel just the right amount of challenge", "My mind is completely clear" and "Something important to me is at stake here".

Intrinsic Motivation is a type of autotelic experience, and reflects wanting to do a behaviour for the behaviour's own sake (as opposed to being extrinsically motivated by a reward/punishment). To investigate potential effects of breaks on intrinsic motivation, the experiment assessed intrinsic motivation through the Intrinsic Motivation Inventory (IMI) [56]. There are several versions of the IMI, the version we use is an 18-item self rating scale, with responses being scored on a 5-point likert scale that ranges from 1 (Strongly Disagree) to 5 (Strongly Disagree). The IMI has previously been used in games research to assess four constructs, with each of these constructs (and their cumulative inference of intrinsic motivation) thought to be pertinent to this investigation of skill acquisition and the player experience. The four constructs of the IMI are:

Interest/Enjoyment is the interest and inherent pleasure when doing a specific activity. Interest/Enjoyment is relevant to this work because players who either enjoy our game or find it interesting will put more effort into performing well and may experience high levels of flow. An example item includes: "I enjoyed this game very much".

Effort/Importance is the individual's investment of their capacities in what they are doing.

This is relevant to our work because players who are more willing to put in more effort may perform better in our task. An example item includes: "I put a lot of effort into this game".

Perceived Competence is how effective individuals feel when they are performing a task. This is relevant to our work because how the participants feel about their own performance may affect how well they are trying to perform in our game. Also a player's competence may affect how they experience flow in our game. An example item includes: "I think I am pretty good at this game".

Pressure/Tension is how much the participant feels influenced or strained during the task. This is relevant to our work because participants may perform differently if they feel pressure to do well in our game. This can also affect player flow states. An example item includes: "I felt tense while playing the game".

3.4 Research Design

This section provides a brief overview of the research programme, which comprises two studies. Each study is a quantitative study designed to look at a primarily player skill progression through a game, with their experience also being observed. As a result, a game was developed in order to test the effects of spaced practice.

3.4.1 Study 1 Overview

Study 1 was designed as a between groups experiment, in which participants play through a bespoke platformer video game. This study primarily focused on determining whether (and to what extent) spaced practice effects occur in a more complex video game than those used in prior research (answering RQ1). As such, participants were split into 2 groups (group α; group β). This study also had a secondary focus, to determine if spaced practice affected flow states and the player experience (RQ3). Once this study was completed, we could then determine how Study 2 would be designed. Study 1 is described in more detail in Chapter 4.

Spaced Practice is used to describe the study condition where players were given a break between gameplay sessions. Participant group α played our platformer using spaced practice, where four 5-minute gameplay segments were broken up by three 2-minute breaks. As mentioned in section 2.1.1, spaced practice can vary in both task and break session length. We decided on 5 minutes of gameplay after doing some pilot analysis determining that players would reach a skill plateau after 20 minutes of gameplay. We decided on just doing 2 minutes, as it 1) seemed the most reasonable length within the design of our game, 2) we already know that various times of breaks worked better than continuous practice from prior research [46]. If we could demonstrate that a 2-minute break is better than continuous practice, it would be reasonable to assume any break would work better than continuous practice. We also wanted to ensure our study could be completed in a reasonable amount of time.

Continuous Practice is used to describe the study condition where players were given little or no break between gameplay sessions. Participant group β played our platformer using spaced practice, with four 5-minute gameplay segments, and a 3-second break between each segment. We considered 3-second rests as continuous practice, as this aligns with prior research about spaced practice within and outside of a video game context [46, 76]. This also ensured our two groups were comparable, with four distinct gameplay sessions in each group.

3.4.2 Study 2 Overview

Study 2 was designed as a between groups experiment, in which participants play through a further altered version of our bespoke platformer video game. This study was primarily focused on the effects of break activities in spaced practice—specifically, if break activities alter spaced practice effectiveness, and if different break activities varied the effectiveness of spaced practice. This study also had a secondary focus, to determine if different break activities affected flow states and the player experience. This was designed to answer research question two and was designed to answer the rest of research question three. Study 2 is described in more detail in Chapter 5.

Break Task is the activity that a participant engages in during a break. We design and categorize our break types based on two constructs, inspired by our assessment of breaks in commercial games mentioned in section 2.5.1:

Task Similarity is how we determine how much a break task resembles the main gameplay task's core mechanics and objectives. We rate task similarity based on a high or low measurement. The higher similarity break tasks will have similar mechanics and objectives to the main gameplay task, while the lower similarity break tasks will differ in mechanics and objectives. This is further discussed in the design of Study 2 (see Chapter 5 for more details).

Task Intensity is used to describe a task's engaging, stimulating, and interactive qualities relative to the main gameplay task. We rate task intensity based on a high or low measurement. The higher intensity break tasks will be more stimulating, either through faster gameplay, more objectives or more complex button inputs relative to the main gameplay task. Lower intensity break tasks will be less stimulating, through slow gameplay, less objectives or few button inputs relative to the main gameplay task. Intensity does not mean more or less difficult, just a difference in stimulation relative to the main gameplay task.

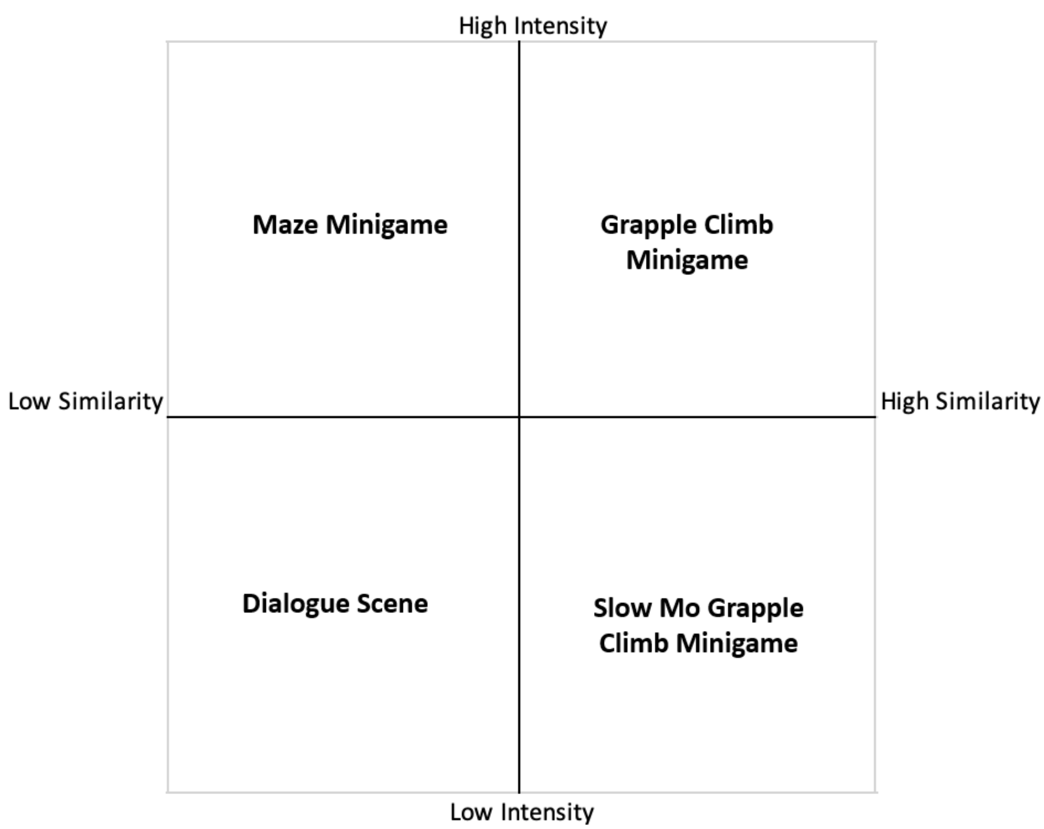

Figure 3.1: Chart shows our breaks on a high and low similarity vs intensity axis

3.5 Experiment System Development

3.5.1 Factors in Designing a Digital Game

To investigate the potential of spaced practice, we needed to develop a game that was relatively more complex than games used in prior research. Research in prior work [80, 57, 46], while showing strong evidence that spaced practice works in video games, used games that had simple controls, simple goals, and designs that did not lend themselves to multiple break types. This presented several factors to consider when designing a game for study. First, it had to involve several mechanics and more actions for the player, more closely resembling a commercial game. Second, while the game had to be complex, it still had to be simple enough that individuals with basic gaming experience could play the game and master it within a short window of time. Third, the game also had to seamlessly support various breaks types that felt natural within the context of the game, as we were going to use this game in our second study on multiple breaks.

Recent work on spaced practice in games [46] used a clone of *Super Hexagon* [19], which has simple controls (i.e., two buttons that control direction), and a simple goal (i.e., avoid obstacles). While this work did show strong evidence that players can benefit from spaced practice, it is unclear whether the results extend to games with complex controls and mechanics. Further, the simplicity of *Super Hexagon*'s design does not lend itself well to the implementation of break activities, such as narrative arcs, quests, or mini-games.

To address the limitations in previous studies of spaced practice in simple games, we applied the following design guidelines in our game: 1) where possible, the game should be ecologically valid (i.e., should be experienced as a game and not an experimental task); 2) the game should involve a wider variety of skills than those that were considered in previous studies; 3) the game should support different in-game break activities; 4) the game controls should be easy to learn with minimal instruction; 5) the game should provide multiple ways to measure performance.

3.5.2 Implementation of the Digital Game

Based on these guidelines, we designed and developed a 2D side-scrolling platformer inspired by *SpeedRunners* [29] (Figure 3.2). In our game, the player controls a lumberjack avatar that traverses an obstacle course that repeats, similar to an infinite runner. Each time they completed the course, it was considered a lap. The goal for the player is to try to complete as many laps as they can within the 5-minute play session. To complete a lap, players run, jump, wall jump, and swing using a grappling hook. The players use left and right arrow keys or the A and D keys to move left or right, and use the spacebar to jump. When the player pressed either the E key or left mouse click, the player would throw the grapple. The game automatically targeted the closest grapple point in the direction the player is facing. The grapple points were bright yellow squares that highlighted red when targeted. Once a grapple was targeted, the player would press the grapple button and would start swinging. If on a platform, the grapple would pull them up slightly in-order to make the initial swinging easier for the player. The player could adjust the length of the grapple by pressing either the up and down arrow or the w and s key. They could use the movement keys to control the direction and speed of the swing. Upon release of the grapple button, the momentum from the swing would launch the player. By releasing at the right moment, the player could leap to the next ledge or grapple point.

The grapple was included as an advanced skill that is easy to learn but hard to master. Since platformers are fairly common and the mechanics in our game, such as jumping to and from platforms, are found in numerous platformers, players could already have the skills necessary to be experts. This would reduce the effects of spaced practice significantly, as spaced practice is most effective in the initial stages of learning [49, 86]. The grapple added a skill most players likely would not have encountered in other games or if they had, would likely have vastly different implementations. This way experts would have a new skill to learn and master throughout their play session.

The obstacle course that the players traversed was fairly simple, focusing on starting off easier and becoming progressively more difficult. The level started by introducing players to the basic movement and jump mechanics. Players started by making simple jumps over ledges, and the leaps across shallow gaps. After a few jumps and leaps, then there was another shallow gap that required the player to grapple across, introducing them to the grapple mechanic. This was then followed by a larger gap that required the player to make two grapples in the air sequentially. The obstacles continued to increase in difficulty, with two sequential grapples at a steeper incline, followed by a triple grapple segment at a steep incline over a large pit. Once completed players would have to

Figure 3.2: screenshot of the 2D platformer

make a grapple to a platform by fully swinging around a grapple point. Then from that platform make another steep grapple to another ledge. The final segment involved the player doing another full swing around a grapple point to a ledge, followed by two sequential grapples that were entirely vertical up to another platform. The last obstacle is another steep grapple that had the player either do a full rotation grapple to a ledge that allowed them to make a large leap or attempt to build momentum to make a large jump from the grapple point itself to the finish flag, where the player would repeat the course again. At no point could the player die or have to restart. Any large pits that the player fell into and could not climb out of had them respawn instantly at a checkpoint just before the jump. This was done for two reasons: first to alleviate some potential frustration for the player that would cause them to lose interest in playing the game, and second to ensure the player focused on attempting the challenges with no fear of severe punishment for failure.

A side scrolling platformer fit our design guidelines well: it is a familiar genre that looks and feels like off-the-shelf games; it involves several combined skills involving hand-eye coordination, timing, and memory; it allows performance improvement over the timeframe of a short study; it supports a variety of game mechanics to be used as break activities; and it allows several performance measures including number of laps, distance travelled, average lap time, and falls. We ran a brief pilot study to ensure players improved on a learning curve, that our breaks worked as intended, and that the game engaged participants in a meaningful way.

3.6 Ethics

Ethical approval was obtained from the behavioural research ethics board at The University of Saskatchewan and participants renewed their consent at the beginning of each component of the experiment. To comply with ethical guidelines, tasks were only available to workers from the United States or Canada who were over 18 years old. Participants were paid $1 USD for the screening task, $6.50 USD for the experiment, and $2.00 USD for the retention task. The screening task took approximately 6 minutes, each experiment took about 26 minutes, and the retention task took about 6 minutes.

4 Study 1: A Game For Evaluating Spaced Practice

We wanted to start our first study by addressing the first research question we had: *RQ1. Does Spaced Practice Work in a More Complex Game*, as mentioned in section 3.2. In addition, this study could also partially answer *RQ3: Do Breaks and Different Break Activities Interrupt Flow*. To achieve our goals, we created our own 2D platformer to test our theories. We did this first to determine if 1) spaced practice worked in our game and 2) if the results remained consistent with prior research. Once we determined that spaced practice worked in our game, we could then confidently move forward to examining different break types. We expected that the spaced practice effect would work in the game we made and the spaced practice participant group would perform better than the continuous practice group. We also expected that spaced practice would not affect how players experienced or engaged with the game significantly.

4.1 Design of Study 1

Similar to past work, we used separate training and retention sessions. The training sessions consisted of playing a total of 20 minutes of our platformer, broken up into four 5-minute gameplay segments and three breaks. We randomly assigned participants to one of two groups, spaced practice or continuous practice. The spaced practice group had 2-minute breaks, where the game would cut to a black screen with a timer counting down. During this time participants were free to use their computer as they wished. Once the break timer expired, an audio cue would play and a continue button would prompt the participant to continue when they were ready. Once the participant pressed the continue button, the next 5-minute gameplay segment would begin. The continuous practice group had a 3-second break that presented itself similarly to the 2-minute break, with a black screen, countdown timer and audio cue to return with a continue button. The 3-second break for the continuous practice group was intended to equalize the experience for both groups, instead of allowing the continuous practice group to play without any interruption. For both groups, the interrupted lap was omitted from the analyses, to avoid skewing the lap times with incomplete data. Participants were also recruited for the 5-minute retention task one week later, which was the same level from the main experiment, completed in one 5-minute gameplay segment without any break.

4.2 Procedure

After providing informed consent, participants completed a demographics questionnaire regarding their overall gaming history, gaming frequency, platformer expertise, play style, gender, and age. Expertise level was self-rated on a sliding scale, from self identifying as a gamer to not at all. Platformer familiarity was also self-rated on a sliding scale from very familiar to not at all. Participants then had to fill out two questionnaires on Attentional Control [26] and Achievement Orientation [43]. Participants then began a brief tutorial on how to use the mechanics of the game. If participants were unable to complete the tutorial under 5 minutes, they did not move onto the next part of the study. For those that completed the tutorial, they would move on to the main experiment. After completing the experiment, participants followed up with three more questionnaires about Flow [97], Intrinsic Motivation [56], and general feedback. After completing the questionnaires, participants were contacted one week later to complete the final step, completing a 5-minute gameplay segment retention task with no breaks.

4.3 Recruitment and Participants

Our online experiments were conducted on Amazon's Mechanical Turk, a system that connects requesters providing paid human intelligence tasks (HITs) to workers. Mechanical Turk has been effectively used for games user research (e.g., [46, 16]) when precautions are taken [30, 54].

We only recruited participants who were not complete novices at games; although spaced practice has been shown to be effective for total novices, the short time frame of a single experiment meant that we needed to ensure that participants had a basic level of proficiency with the game's controls. We therefore used a screening task that assessed whether players could operate the controls; any players who could not complete the task within 5 minutes were not recruited for the full experiment (the tutorial could be completed in as little as 30 seconds).

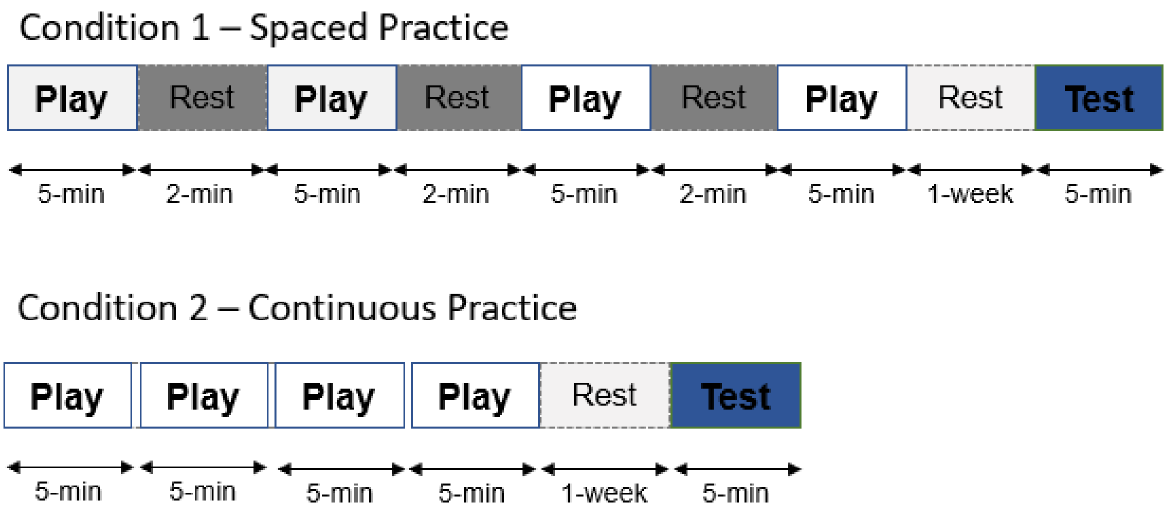

Figure 4.1: Visualization of our procedure for the experiment

A total of 80 participants completed our experiment. Of these, we excluded 18 participants from our analysis due to them not having completed at least one lap in each session and a further 7 participants for having spent a longer time on their breaks than intended (> 1 SD than average). This left us with 55 participants, 41 of which identified as a man, 13 of which identified as a woman, and 1 who identified as non-binary. The participants had an average age of 34.2 (min=21, max=52, SD=6.69). 31 participants received a 2-minute break between sessions, and the remaining 24 completed the game under continuous practice. Measuring the actual break time of the filtered participants, we found that those who were given a 2-minute break rested for an average of 127 seconds between segments (min=122, max=148, SD=7.29) while those given a 3-second break rested an average of 14.9 seconds between segments (min=4.59, max=42.4, SD=12.2).

For retention, we invited participants back with an email via MTurk's application programming interface that provided a URL to the task. Only the 55 participants who completed at least one lap per segment, and who were not excluded for resting too long received an email. Of these, 50 completed the retention session; 27 of whom had completed training under spaced practice.

We used our trait measures to ensure there were no trait differences between the groups. This was done with a one-way analysis of variance test for each measure, with 'break' as a between subject effect. We found no significant differences between the groups, seen in 4.1 (all $p \geq .185$).

Variable	F	p
Video Game Experience	1.79947	0.185
Platformer Experience	0.38200	0.539
Attentional Control	1.61e-4	0.990
Win Orientation	0.03548	0.851
Competitiveness	0.03548	0.851
Goal Orientation	0.26176	0.611

Table 4.1: Results of statistical tests on the trait variables for Experiment 1.

4.4 Analyses

To verify that spaced practice positively affected performance in our platforming game, we computed separate repeated measures analysis of covariance (RM-ANCOVA) tests for Average Lap Time and Distance Travelled, with Segment as the within-subjects factor and Break as the between subjects factor. Instead of Segment 1's performance being included as a repeated measure it was used as a covariate, as suggested by [94]. Additionally, gamer identity, platforming familiarity, and win orientation were used as covariates based on correlations with our performance measures; no other covariates correlated with the performance measures.

To analyze subjective experience (which were not measured after each segment), we performed a multivariate analysis of covariance (MANCOVA), using the subscales of the FKS and IMI as dependent variables. Break was used as a between-subjects factor, and the covariates used were self-rated gamer identity, platforming familiarity, attentional control, competitiveness, win orientation, and goal orientation.

For the retention data, assessed one week after the main experiment, separate analyses were performed. For the performance results, separate ANCOVA tests were used for average lap time, distance travelled, and for each of the subjective player experience measures. The same between subjects factors and covariates were used as in the main experiment.

Alpha was set at 0.05, all covariates were mean-centred [95], and all pairwise comparisons used the estimated marginal means and Bonferroni corrections. Degrees of freedom for within-subject effects were corrected with Huynh-Feldt estimates of sphericity [34] (as sphericity estimates >.75).

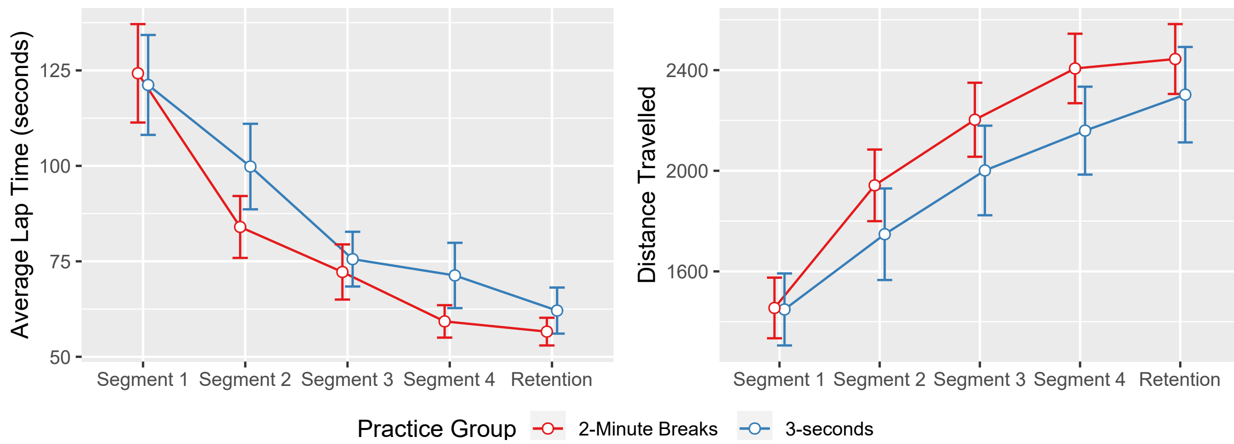

Figure 4.2: Performance results for Experiment 1. Error bars show standard error.

4.5 Results

We first present the results for our performance measures, followed by the subjective measures of player experience.

Did Performance Change Over Time?

We found that participants did improve at the game during the Training Session. They completed laps in less time ($F_{1.77,86.8} = 27.5$, $p < .001$, $\eta_p^2 = .360$) and travelled greater distances ($F_{1.78,87.3} = 48.7$, $p < .001$, $\eta_p^2 = .498$). Comparing between the Segments, we find improvements to performance (time and distance) between Segment 2 and 3, as well as between 2 and 4 ($p < .001$), but between Segment 3 and 4, there were only improvements to distance travelled ($p < .001$), not lap time ($p = .065$).

We found no significant interaction between Segment and Break for lap time ($F_{1.77,86.8} = 2.06$, $p = .140$, $\eta_p^2 = .040$) or distance travelled ($F_{1.78,87.3} = 0.05$, $p = .940$, $\eta_p^2 = .001$).

Were There Benefits to Spacing Practice?

For the Retention Session, we found that the benefits to spaced practice persisted after a week of not playing the game. There was a significant main effect of Break on performance of the retention task, for both average lap time ($F_{1,43} = 4.41$, $p = .042$, $\eta_p^2 = .093$) and total distance travelled ($F_{1,44} = 4.21$, $p = .046$, $\eta_p^2 = .087$).

Did the Break Affect the Subjective Experience?

No. There was no significant main effect of Break on any of our measures of subjective experience (including flow, worry, pressure, enjoyment, effort, and competence), for both the Training Session (all $p \geq .210$), as well as the Retention Session (all $p \geq .119$). See Table 4.2 and 4.3 for descriptive statistics. In particular, there were no differences in experienced Flow ($F_{1,47} = 0.755$, $p = .389$ for Training, $F_{1,42} = 0.236$, $p = .630$ for Retention) or Enjoyment of the game ($F_{1,47} = 0.076$, $p = .751$ for Training, $F_{1,42} = 2.53$, $p = .119$ for Retention).

		Flow	Worry	Pressure	Interest-Enjoyment	Effort	Competence
Experiment	Group	Training	Training	Training	Training	Training	Training
Experiment 1	2-minute break	5.08 ± 0.80	3.51 ± 1.52	2.77 ± 1.05	3.54 ± 0.81	4.15 ± 0.58	3.83 ± 0.79
	3-second break	4.90 ± 0.91	3.82 ± 1.50	2.89 ± 1.11	3.62 ± 0.99	4.29 ± 0.67	3.71 ± 0.82
Experiment 2	Low Intensity	4.92 ± 1.09	3.45 ± 1.23	2.80 ± 1.07	3.56 ± 0.96	4.25 ± 0.67	3.78 ± 0.81
	High Intensity	4.84 ± 1.15	3.26 ± 1.50	2.78 ± 1.03	3.37 ± 1.08	4.14 ± 0.71	3.49 ± 0.94
	Low Similarity	4.84 ± 1.14	3.46 ± 1.39	2.81 ± 1.08	3.43 ± 1.03	4.17 ± 0.76	3.63 ± 0.86
	High Similarity	4.91 ± 1.11	3.25 ± 1.36	2.77 ± 1.01	3.49 ± 1.03	4.22 ± 0.61	3.63 ± 0.93

Table 4.2: Descriptive statistics for the subjective measures during training, for both Experiment 1 and 2. Error is standard deviation.

		Flow	Worry	Pressure	Interest-Enjoyment	Effort	Competence
Experiment	Group	Retention	Retention	Retention	Retention	Retention	Retention
Experiment 1	2-minute break	4.96 ± 0.99	3.48 ± 1.44	2.52 ± 0.90	3.55 ± 0.85	3.94 ± 0.84	3.85 ± 0.72
	3-second break	5.08 ± 0.88	3.97 ± 1.18	2.79 ± 1.17	3.89 ± 0.77	4.07 ± 0.81	3.83 ± 0.72
Experiment 2	Low Intensity	5.11 ± 1.01	3.60 ± 1.10	2.67 ± 1.07	3.78 ± 0.84	4.26 ± 0.60	3.85 ± 0.83
	High Intensity	5.01 ± 0.96	3.31 ± 1.36	2.53 ± 1.01	3.49 ± 0.95	4.09 ± 0.69	3.84 ± 0.77
	Low Similarity	5.09 ± 0.97	3.57 ± 1.26	2.53 ± 1.04	3.72 ± 0.87	4.22 ± 0.68	3.95 ± 0.68
	High Similarity	5.02 ± 1.00	3.32 ± 1.25	2.66 ± 1.03	3.52 ± 0.95	4.12 ± 0.62	3.74 ± 0.88

Table 4.3: Descriptive statistics for the subjective measures in the retention task, for both Experiment 1 and 2. Error is standard deviation.

4.6 Summary

For our first study we wanted two address two of our research questions: RQ1) does spaced practice work in a more complex game and RQ2) do breaks during spaced practice affect flow? To answer these research questions, we designed a 2D platformer video game that was more complex than prior research. The game had players use a wide variety of skills and mechanics, in order to improve over several gameplay sections. Players were then split into two groups, a continuous practice and spaced practice condition. Each section was broken up into a two-minute break where players were free to use their computer as they wished or a 3-second break interval. After they were done with all sections, they were invited back one week later for a retention task, to determine if the effects of spaced practice persisted after training.

For RQ1, we did find that spaced practice worked in our platformer. We found that players made strong initial gains during their training, that eventually evened out by the last gameplay sections. We found that spaced practice was more beneficial than continuous practice. Players in the spaced practice condition completed laps in less time compared to the continuous practice group, and the effects persisted one week later.

To answer RQ3, we had participants fill out questionnaires on their enjoyment, flow, and experience playing the game. We found that break had no significant main effect on the player experience. This only provided us with partial answers for our questions about the effects of breaks on flow.

Study 1 confirmed that spaced practice improved performance in our game over continuous practice, similar to results seen with simpler games in different genres. It also provided indication that spaced practice does not affect how players experience the game. Knowing this, we wanted to see if players could do any other activities during a break and get the benefits of spaced practice. By doing this, we could also determine if there is an optimal task to do during a break and determine if player experience is benefited by having break tasks.

5 Study 2: Evaluating Break Types

Now that we know spaced practice works in our game and have provided additional evidence for its benefits in games, there are some raised concerns around implementation of breaks. While players seemed unbothered by the breaks in study one, at least in terms of impacting flow, this was over a 20-minute experience for an experiment. Implementing breaks as a blank screen in commercial games would likely annoy players, causing them to quit playing. However, as mentioned previously in section 2.5.1, many games have activities or tasks that could be considered breaks, separate from the main gameplay task. Game designers provide different types of breaks (e.g., cut scenes, dialogue, mini-games, loading screens) and should be able to choose break designs knowing: 1) if the activity would affect how players perform and experience the game; and 2) if one type of break is more beneficial than another at supporting performance improvements. If all break types work equally well, then designers would have the freedom to choose break activities that best support their design goals.

After determining that the spaced practice effect occurred in our platformer, we then moved onto our second study. The second study was designed to address our second research question from section 3.2: *RQ2. Does the Type of Break Activity Affect Player Performance*, and provide further confirmation of the third research question: *RQ3. Do Breaks and Different Break Activities Interrupt Flow*. We predicted that break activities would affect the benefits of spaced practice. If our predictions were correct, we could also determine if different types of breaks affect the spaced practice effect in video games differently. We suspected that tasks that are less similar and less intense to the main task will have greater benefits to spaced practice. After determining how breaks affected player performance, we could then determine how it affected player experience and flow. We predicted that player would like breaks that had lower intensity, but the higher similarity and higher intensity breaks would be better for flow.

5.1 Developing the Break Types

We developed our break activities to resemble those found in commercial games. We did this to ensure our game felt more like a game players would encounter outside of research and that our results would be more generalizable to the wider scope of games outside of the specific genre we chose. We did this while focusing on our two break design dimensions of similarity (how close the activity was to skills needed during the primary game task) and intensity (the level of interaction needed to conduct the activity). We built activities with high and low amounts in each dimension, to encompass a wide range of game activities. For similarity, high similarity activities used mechanics from the main game, such as jumping and grappling, had the player interact in a similar way, and were presented in a similar way to the main game play task. Low similarity tasks used mechanics not used in the main game, changed how the players would interact with the game, and had goals that were different from the main games goals. For creating different tasks based on intensity, high intensity activities required the player to make quick reactions and decisions, while requiring the same or more interactions and button presses as the main game. In contrast, low intensity tasks involved limited input without the need for quick reactions.

This resulted in us creating four unique break types based on our dimensions of high and low similarity and interaction.

For the low similarity, low interaction break task, we created a dialogue scene between the player character and a mountain man NPC. The dialogue scene had the player making meaningless but humorous binary dialogue choices through a space bar press or mouse click, with no platforming or movement involved, as seen in figure 5.1 . By having no movement, platforming, or methods of failure, this created a more relaxed and effortless experience unlike the main game.

For low similarity, high intensity break tasks, we created a maze mini-game where players were told to navigate a maze to find all the hidden collectible gems, seen in figure 5.2. The goal of finding the gems differed from the main game goal of completing a lap as fast as possible, requiring the player to use navigation and memory skills, rather than reflexes and motor memory skills. Players were also unable to jump, instead having to learn a new simple ladder climbing mechanic not found in the main game, making a task that was not like the main game but requiring a lot of engagement and interaction from the player.

Figure 5.1: The dialogue break, used as the low similarity and low intensity break

For high similarity, high intensity, we created a grapple climbing mini-game, seen in figure 5.3, where players had to grapple up a series of grapple points to get as high as they could. This break used the exact same controls as the main game, with the only minor difference being the goal to climb as high as possible and a lack of emphasis on avoiding obstacles. However, the players had to use the most timing intensive mechanic in the game, the grapple, while having no checkpoints or safety points upon missing a grapple. This created a faster and higher pressure experience than the main game.

Finally, for high similarity, low intensity, we used the same grapple mini-game from the high similarity, high intensity break, but slowed down the play speed to fifty percent, making a slow motion version of the mini-game in figure 5.3. This allowed players to time their jumps from each grapple point much easier, making the chances, and pressure, of a miss much smaller. This also made recovering from a missed grapple much easier, since falling was slowed down as well, giving the player more time to perceive and time recovery grapples.

Figure 5.2: The maze break, used for the low similarity and high intensity break

5.2 Design of Study Two

Instead of allowing participants to use their computer freely, as was done in Study 1 based on previous work [46], in Study 2, we randomly assigned participants to one of four break conditions, described in Section 5.1. The game duration was still 26 minutes, with the game broken up into four 5-minute gameplay segments, with three 2-minute break tasks determined based on experiment condition: Dialogue (low Similarity, low Intensity), Grapple Mini-game (high Similarity, high Intensity), Slo-Mo Grapple Mini-game (high Similarity, low Intensity), and Maze mini-game (low Similarity, high Intensity). To track whether participants engaged with the breaks or not, we kept count of the number of times they pressed the main interaction key in each break, as well as player movements for the grapple mini-games and maze breaks. Once the two minutes had expired, the task would automatically stop and a button to continue to the next gameplay segment appeared. Participants could press the button when they were ready to continue.

Participants who were not excluded were recruited for the 5-minute retention task one week later. The task was the same level from the main experiment, completed in one 5-minute gameplay segment without the breaks.

Figure 5.3: The climb break, used for high similarity, and both ends of intensity

5.3 Procedure

The procedure for this study worked similarly to Study 1. We used the same questionnaires, asked for the same demographics, used the same tutorial, the same game, and participants were invited back in the same way for the same retention task. This was done to ensure that these results could be at least visually comparable to the results of the previous study. The major difference for this study is that there were four conditions, each with different activities to do when players had their break. There was also no continuous practice condition, as the results from the last study were usable for comparison.

Participants gave informed consent first and then completed the tutorial prescreen study. If they were successful in completing the tutorial in five minutes, they were invited back for the main study. They gave informed consent and were assigned to the condition with the fewest participants to ensure there were an even number in each condition. Then they filled out the demographics questionnaire and achievement orientation questionnaires. After completing the questionnaires, they played 26 minutes total of the platformer game. Once they completed the game, participants filled out questionnaires about their experience. After a week, participants were invited back for a

Figure 5.4: Visualization of our procedure for the experiment, a modified version of the spaced practice condition from experiment 1

retention task where they played five minutes of the same platformer with no breaks and answered questionnaires about their experience.

5.4 Participants

A total of 226 participants (who did not participate in Study One) completed Study Two. To ensure data quality, we excluded participants based on several criteria. First, our server crashed during the experiment and as a result, some participants attempted the game more than once or their data was not logged correctly (n=37). Of those that remained, we excluded participants who did not complete at least one lap in each of the four sessions (n=37). We further excluded participants based on whether they diligently observed our two-minute break time; determined by the participants taking a break within 1 standard deviation of the mean break time (mean break of 135 seconds, SD=24.3; n=11). There were no exclusions based on interaction during the break, as every participant interacted with the game during the breaks. We removed outliers in terms of platforming familiarity, as they were unevenly distributed among the groups (n=2, using a cut-off of platforming familiarity > 10). Our final exclusions were made based on participants entering an invalid age (n=2, < 18 years old).

As such, we analyze data for 137 participants with an average age of 32.1 (min=18, max=49, SD=6.51). Of these, 101 identified as men, 34 as women, 1 as non-binary, and 1 preferred not to answer. In terms of experimental condition, 32 participants experienced Dialogue (low Intensity, low Similarity), 34 experienced the Grapple Mini-game (high Intensity, high Similarity), 34 experienced the Slo-Mo Grapple Mini-game (low Intensity, high Similarity), and 37 experienced the

Maze Mini-game (high Intensity, low Similarity).

The Retention Task was completed by 193 players. Considering only those whose data were included in the first stage, we analyzed Retention Task data for 115 participants.

5.4.1 Analyses

The analyses used for Study 2 were very similar to those used for Study 1. For performance, we once again used a RM-ANCOVA for each of our two dependent measures of performance—average lap time and total distance travelled. Segments (2, 3, and 4) were used as the repeated-measure factor, with Segment 1 as a covariate. Intensity and similarity were used as two between-subject factors with two levels each (low and high). Note that we also tested the breaks as four levels of a single factor, and results did not change. Participants' self-rated familiarity with side-scrolling platform games and self-identification as a gamer were also included as covariates. For distance travelled, the assumption of sphericity was violated, so Huynh-Feld correction was used [34].

To determine differences in subjective experience (which were measured for the entire Session, not for each segment), we performed two-way ANCOVAs for each subscale in the FKS and IMI as dependent variables. Intensity and similarity were used as between-subject factors. Self-rated gamer identity, platforming familiarity, attentional control, competitiveness, and goal orientation were included as covariates.

For the retention data in Study 2, data were analyzed in the same way as Study 1.

For all tests, covariates were selected on the basis of whether they correlated with our dependent measures. All covariates were mean-centred [95], and all pairwise comparisons were made using Bonferroni corrections. To check whether the groups had skewed trait measures, two-way ANOVAs were calculated for each of our trait measures with intensity and similarity as between subject factors. No trait measure had significant main effects of intensity or similarity, except for platforming familiarity, which had a significant main effect of intensity ($F_{1,133} = 5.32$, $p = .023$), indicating that the participants in the low intensity version of the break were more familiar with platform games. Therefore, platforming familiarity was used as a covariate in all analyses.

5.4.2 Results

We first present results for performance, followed by measures of player experience. See Table 5.1 for statistics and descriptive statistics and Figure 5.5 for results.

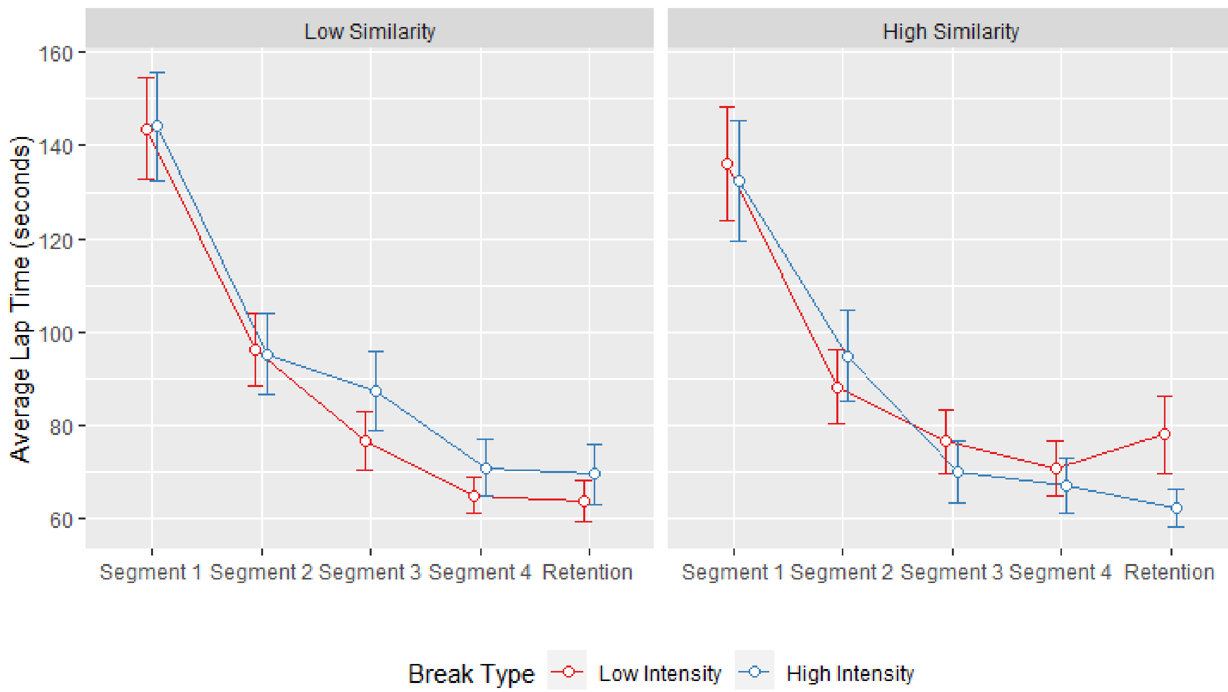

Figure 5.5: Average lap time for Experiment 2. Error bars show standard error.

Did the Breaks Work?

Before comparing the effects of the various breaks, we first present performance results for the four break types as compared to the uncontrolled spaced practice and continuous practice from Study 1. As these were two separate experiments with different samples of participants, we do not provide statistical comparisons between these six groups; however, Figure 5.7 visually shows the improvement in average lap time and distance travelled for the four break types and the 2-minute and 3-second groups from Study 1 together. Controlling for performance in Segment 1, it is clear that performance does still improve when participants engage with in-game break activities. The remainder of the results focus only on the sample of participants in Study 2.

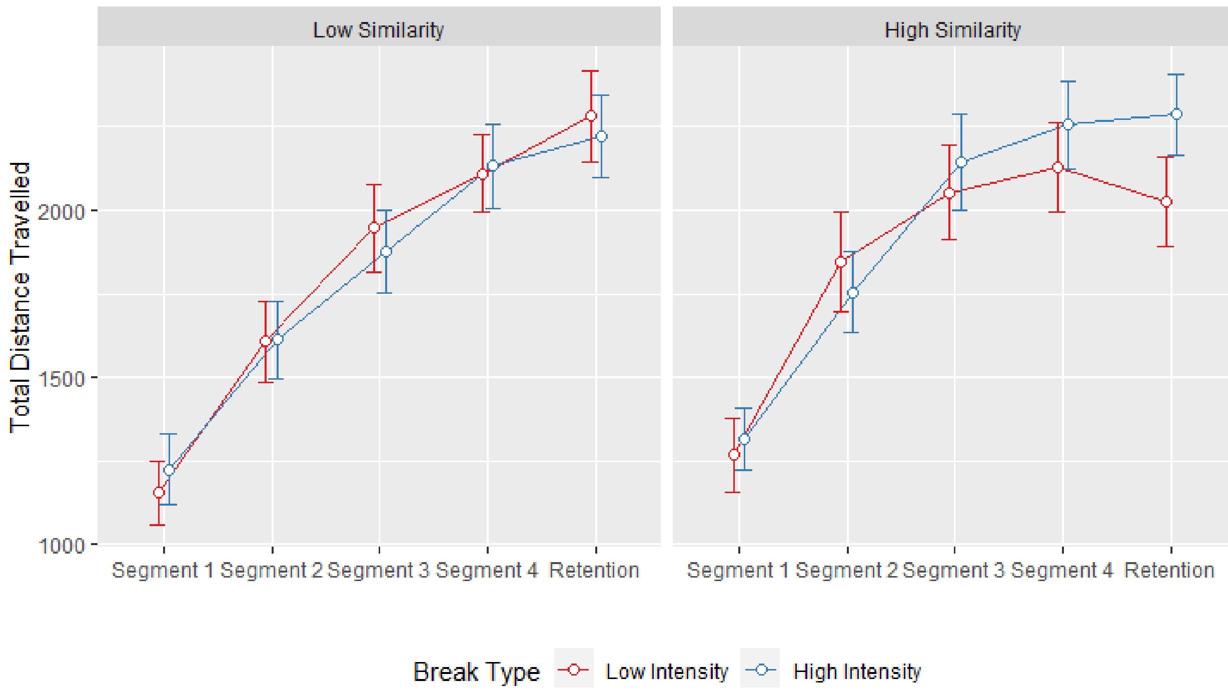

Figure 5.6: Total distance for Experiment 2. Error bars show standard error.

Did Performance Change Over Time?

Yes. We found a significant main effect of Segment on performance, for both average lap time ($F_{2,260} = 59.6$, $p < .001$, $\eta_p^2 = .314$) and total distance travelled ($F_{1.79,232.5} = 107.6$, $p < .001$, $\eta_p^2 = .453$), when controlling for Segment 1's performance. Pairwise comparisons revealed that every Segment was different from the others (all $p < .001$). This indicates that participants' performance improved significantly over time.

There was a significant interaction between segment, intensity, and similarity for average completion time ($F_{2,260} = 3.97$, $p = .020$, $\eta_p^2 = .030$).

Did Intensity or Similarity Affect Performance?

No. We found no main effect of intensity or similarity on average lap time or total distance travelled (see Table 5.1). There were also no significant interactions between intensity and similarity. Retention performance was also not affected by the intensity or similarity of the breaks (Table 5.1).

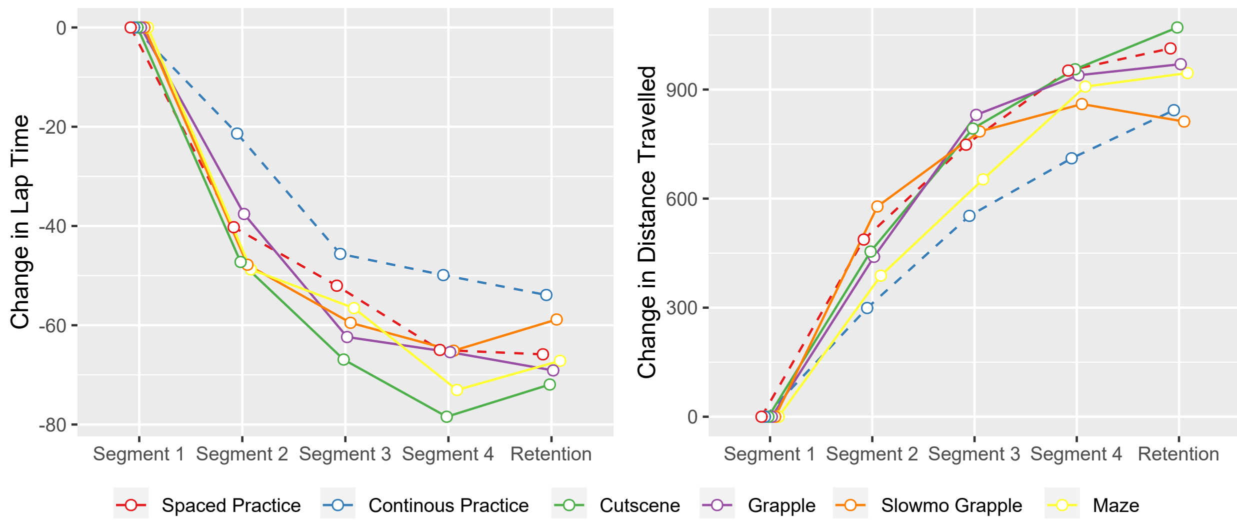

Figure 5.7: Performance deltas from Segment 1 for all groups from Experiment 1 and 2.

Did Intensity or Similarity Affect the Subjective Experience?

No. We found no significant main effects of intensity or similarity on any measure of subjective experience, for both Training and Retention (see Table 5.1). We also found no significant interactions between intensity and similarity. See Table 4.2 and 4.3 for descriptive statistics.

5.5 Summary

After answering our questions about spaced practice in more complex games in Study 1, we used the same platformer for our second study. By confirming that the effects of spaced practice occur in our platformer, we were curious if doing different activities during spaced spaced practice would impact the performance and learning gains for participants.

We needed to create a framework in order to determine which breaks we were going to implement and how we could compare them. Based on past work on spaced practice, task switching and analyzing commercial game examples, we determined that similarity and intensity would be the best way to compare break types. After finalizing our framework, we implemented four different break types in our platformer. Each break will have high or low similarity and intensity compared to the main gameplay task.

Our second study addressed two of our research questions: RQ2) do different break types affect performance gains from spaced practice and RQ3) did break type interrupt the players flow? For RQ2, we found that player performance did change over time in a similar manner to the spaced practice condition from Study 1 and did better than the continuous practice condition. We found that neither similarity nor intensity affected how well the players performed. These results persisted one week later during the retention task.

Finally neither similarity nor intensity affected the player's subjective experience or flow. This provided the complete answer to research question three, started in Study 1.

Measure	Group	Intensity F	Intensity p	Intensity η_p^2	Similarity F	Similarity p	Similarity η_p^2	Similarity*Intensity F	Similarity*Intensity p	Similarity*Intensity η_p^2
Average Lap Time	Training	0.16	.690	.001	0.02	.898	.000	0.24	.627	.002
	Retention	0.20	.316	.009	0.20	.655	.002	2.25	.136	.020
Distance Travelled	Training	0.12	.728	.001	0.53	.469	.004	0.32	.575	.002
	Retention	0.81	.370	.007	0.77	.384	.007	1.35	.248	.012
Flow	Training	0.07	.798	.001	2.06	.153	.016	3.64	.059	.028
	Retention	0.05	.832	.000	0.27	.603	.003	0.86	.356	.008
Worry	Training	0.93	.338	.007	0.05	.817	.000	2.40	.124	.018
	Retention	1.05	.307	.010	0.48	.488	.005	0.30	.583	.003
Pressure	Training	0.77	.383	.006	0.46	.499	.004	2.46	.119	.019
	Retention	1.90	.171	.018	0.00	.947	.000	0.00	.962	.000
Interest-Enjoyment	Training	0.78	.380	.006	1.51	.221	.012	0.00	.975	.000
	Retention	1.35	.248	.013	0.35	.557	.003	0.77	.384	.007
Effort	Training	1.35	.248	.013	0.35	.557	.003	0.77	.384	.007
	Retention	0.50	.481	.005	0.12	.726	.001	0.04	.836	.000
Competence	Training	3.07	.082	.023	0.23	.633	.002	0.85	.358	.007
	Retention	0.21	.645	.002	0.55	.461	.005	0.36	.549	.003

Table 5.1: Results of statistical tests for Experiment 2. Degrees of freedom for subjective measures: Training (1,128); Retention (1,106). Degrees of freedom for performance measures: Training (1, 130); Retention (1,108).

6 Discussion

In the following chapter, we address our main research questions about spaced practice and breaks in games. First we consider possible explanations for the questions based on the results of our two studies. Following this we discuss the possible implications for game design and how breaks could possibly be used in game design. Finally, we discuss the limitations of our work and the possibilities of future work with spaced practice in games.

6.1 Research Questions

RQ1. Does Spaced Practice Work in More Complex Games?

Our results indicate that spaced practice improves skill development in a 2D side-scrolling platformer that requires multiple coordinated skills. Experiment One showed that taking breaks led to significant gains over continuous practice over the course of the play session. Both experiments showed that spaced practice resulted in improvements over time, in which participants made significant gains in the beginning and made fewer gains over time. The retention tasks in both experiments also show that the benefits of spaced practice persisted a week later, with players performing better than those who did continuous practice.

This result is an important extension to previous work that has studied spaced practice in simple games—our results provide empirical evidence that the complexity of games is not a barrier to making use of the spaced practice effect. It is possible, however, that spaced practice will not foster improvements in different game genres, such as shooters or role-playing games, or will not benefit performance as strongly as we demonstrate. The spaced practice effect does not apply in all tasks (e.g., [101, 61, 51]); however, the literature shows that it is generally advantageous to take breaks (see Section 2). Although we cannot state unequivocally that spaced practice will benefit performance in all complex games, our results show that it is effective in a platformer. Although further study is needed to replicate our results in other game genres, many kinds of games use interactions and skills that are similar to those in our platformer, and it is likely that our results will generalize at least to these types of games.

RQ2.Does the Type of Break Activity Affect Player Performance?

Our results show that all of the break activities worked equally well—they showed no difference in terms of their effectiveness for player improvement. The breaks had no significant difference between each other, or the spaced practice condition from Study 1. This is an important finding, because designers may have previously considered some kinds of break activities as 'too similar' or 'too intense', but our results show that the value of spaced practice is highly resilient.

We note that the Dialogue break (low similarity and low intensity) did perform best in our sample (see 5.7), but the differences were not significant, suggesting that if there are differences between different levels of similarity and intensity, they are not substantial. It does fit with our predictions that a break that is has the least intensity and least similarity to the main task would make the best break activity. However this does not mean that all break types that fit into the low similarity and low intensity category will yield similar results. Other break types that fit into this classification, such as loading screens and menus may affect spaced practice differently than a dialogue scene. In addition, these breaks were designed to fit in a platforming game and therefore the results may differ depending on game genre. Further study is needed to evaluate more break types and how they work in other games, but our findings will likely generalize to similar break types in similar genres of games.

RQ3. Do Breaks and Different Break Activities Interrupt Flow?

Our results show that breaks overall, regardless of activity or lack of activity, did not affect player flow or experience. Study 1 showed that having breaks, even if they had nothing for the players to do, did not negatively affect flow states. The spaced practice group's flow did not significantly differ from the continuous practice group, meaning that the breaks did not negatively or positively affect player flow. Study 2 answered the second of half of this research question showing that the different break activities did not affect flow. In both experiments retention tasks there were no breaks. Player flow was also unaffected by the absence of breaks. The other experience measures we used did not significantly differ across experiments or retention tasks.

These results provide important insight into how the player experience changes with breaks. Conventional thinking would expect constant starts and stops would have a detrimental effect on flow and experience, but this is not the case. Interestingly, the presence of different activities also did not have a positive effect on flow or experience. This provides designers with a lot of freedom when implementing breaks. In addition to our findings for RQ2, designers now have evidence that both performance and experience are unaffected by breaks, making spaced practice and breaks easier to implement. Further study is needed however, as our implementation of breaks was over a short period in a game designed to evaluate performance gains. While these results provide a good start to evaluating the relationship between player experience and breaks, other factors such as break types in various genres, break lengths, game lengths and break implementation could alter player flow and experience.

6.2 Explanation of Results

6.2.1 Why Were the Different Breaks Equally Effective?

There are numerous theories and factors that explain why spaced practice may work. Previous research suggests that the value of spaced practice comes from giving the brain time to generalize and compile feedback that has been gathered during a training session [76]. The similar effectiveness of all of our break activities suggests that a change may actually be as good as a rest—even when the change is a small one, and even when the change maintains the intensity level of the main game.

Another factor that could explain why there was no significant difference between the break types is due to the break preventing mind wandering. One suggestion for why spaced practice works is that people spend less time with a task constantly, preventing them from getting bored and having their mind wander [59]. By just breaking up the monotony of performing the same platforming tasks, players' minds were able to engage due to the new stimulus.

Research into task switching and switch cost also provides some explanation for our findings. Switching from an unfamiliar task to a familiar task has less of a cost to performance than the inverse [72]. This means that when players switched to their break task, their performance in the break task could have seen a decline, but when they went back to the main task, they were able to retrieve the necessary skills for that task with minimal issue. Players also could have been influenced by the preparation effect, where by knowing that a break was going to occur and have set duration, they were able to anticipate and reduce the effects of the switch cost [60]. So our breaks may have had a different impact had players not known about them ahead of time or had they been implemented in a consistent and predictable way.

6.2.2 Why Did High-Similarity Activities Work Well?

It is clear that if the break activity was exactly similar to the main game, it would equate to continuous play and would undermine the spaced practice effect. The effectiveness of our high-similarity activities, however, suggest that we can design break tasks that are fairly close to the action of the main game without problems—although more study is needed to explore the issue of how close is too close. Previous work found that increasing or decreasing the similarity of a break task had little effect on performance [60], noting that the important factor might actually be giving time for participants to prepare for the switch.

A study by Gillie and Broadbent [44] considered the effect of interruption length and similarity in simple arithmetic tasks. They found that simple similar interruption tasks did not disrupt performance in the main task. Participants were presented with a task that did not require them to immediately start attending to it, similar in nature to our breaks. In our study, the predictable breaks gave players time to prepare for the switch, plus we warned them that they would be returning to the task, potentially reducing the cost of task switching during the breaks. An alternative explanation, proposed by [8], is that tasks performed closer together in time have a priming effect or some residual activation. Residual activation means that players have an association with the tasks left over from the prior attempts, allowing them to boost their starting level on the next attempt. Priming implies that any part of the tasks that have similarity will allow some overlap of skills.

6.2.3 Why Did High-Intensity Activities Work Well?

We expected that increasing the intensity of a break activity would add to players' cognitive load and reduce their ability to compile and generalize training feedback. However, this was not the case: high-intensity tasks were as effective as low-intensity ones. It may be that participants were able to create a plan for how to deal with the break task [76], and then retrieve that plan when the task occurs again. In addition, it is possible that people have enough cognitive resources to both engage in a break activity and carry out generalizations about the main game skills at the same time.

Performance may degrade over time due to physical and cognitive fatigue [96] and breaks may allow players to rest from the fatigue. Since the low intensity break is going to be less strenuous than the main task, the players are getting a rest. As for the high intensity sections, the low similarity section is different enough that the players are practicing a different skill. By practicing this different skill, they get a break from the main task still. As for the high similarity high intensity task, the potential performance loss may be offset by it acting as training for the main task. While not being exactly the same, it did allow players to focus on one skill applicable to the main game and let them improve that skill, allowing them to perform better in the main task.

6.2.4 Why Was Player Experience Not Affected by Break Activity Type?

We did not expect to see significant differences in player experience, because the dominating aspect of play experience was the 20 minutes of engaging with the core platformer mechanics—which was the same for all players—and not the 6 minutes of break activity. It could have been that the participants experienced the breaks so differently that it influenced their overall experience ratings; however, the flow and motivation of players was dominated by the primary task, and not the break activity. Players were also informed that breaks were occurring every five minutes, meaning they were prepared for the incoming break. This likely changed how players experienced the game, as most games would not inform you of breaks in such a direct manner.

It could also be due to the experience being relatively short, meaning that they did not play long enough to develop significant investment into the game where breaks could influence their experience. While some players provided feedback that they found the game frustrating, they likely did not play the game long enough to get to the point where their frustration or boredom overcame their motivation to perform well. This makes sense, as the player's performance gains towards the end of the play time start to plateau. Since players would likely stop making meaningful performance gains, they would probably be more frustrated by the game. The breaks at this point could potentially affect how players experienced the game, possibly adding, alleviating or not impacting frustration.

6.2.5 Why Was Flow Unaffected by the Breaks in Experiment One?

In Experiment 1, there was no difference in flow (as measured by the FKS) between spaced practice (2-minute break) and continuous practice (3-second break). The lack of difference suggests that short breaks may not interfere with flow states, in spite of the interruption to task focus. It is possible that the performance improvements gained by taking a break offset the interruption to task focus by better attuning players to the challenge-skill balance. It is also possible that flow is simply not undermined by the presence of relatively short breaks. Either way, this indicates that flow states in games may be less fragile than previously considered.

6.3 Implications for Spaced Practice

Our results have several implications for game designers. First is further evidence that the spaced practice effect works in video games, in both the short term and long term. Many games have similar skills and complexity to ours, and while there are games that are significantly more complex, it is likely that our findings will generalize to even more complex games. Many commercially successful games are highly complex, and ensuring well-designed performance progression and gameplay pacing is crucial to effective design. One key place this could be applied is in difficulty balancing for video games. It is becoming increasingly common for game designers to decrease a game's difficulty when they detect that players are struggling; game designers could instead consider adding breaks to challenging gameplay sections to assist players with skill acquisition that they will need as they continue to progress. This will help players avoid frustration and allow them to succeed on their own merit while keeping the intended challenge of the original game design.

In the long term, another implication is designers can create games that ensure player skill is retained for longer if players quit playing the game and return. This could be particularly beneficial for single player games that release content over the course of a long period of time. They do not need to worry about players forgetting how to play their game and deciding not to come back if new content comes out. Also implementing spaced practice could remove the need for lengthy tutorial sections that can frustrate players on subsequent playthroughs, as they will likely retain more skills when revisiting a game after some time away from the game and will not need the tutorial. However, our findings may not generalize to games where performance may have a different operationalization. There are significant differences between an action video game versus an RPG when it comes to player performance, and our results may not generalize well to games that define good performance differently.

6.4 Implications for Break Types

The second important finding in our research is that the performance gains of spaced practice can be gained across several different types of break activity. This result implies that designers have the freedom to implement break types that are contextually appropriate, rather than needing to optimize around a better-performing activity that may feel out of place. This also means designers likely do not have to worry about having multiple break types within the same game. With our findings, since all break types acted equally, it is likely that they would not influence performance if the player experienced multiple break types within a certain game context. This gives designers not only a lot of freedom with implementing breaks, but also how many breaks types they can have. While additional activity types should be tested in future work, our results suggest that game designers have a great deal of flexibility in the type of breaks they can utilise.

While our research indicated that even similar and intense activities are effective as breaks, further study is needed. In particular, a break task that is so similar to the main task (as to be almost identical) would very likely negate the spaced practice effect. Our studies indicate that game designers are safe when considering break designs that are experientially different, such as cut scenes or easier gameplay tasks, and can consider breaks that are more intense and similar (like our grapple mini-game); however, further research is needed to determine when breaks are so similar to the task that the experience is one of continuous practice.

6.5 Player Experience

The third finding is that flow is not undermined by the presence of a 2-minute break, and that flow is not negatively affected by the type of break that players take. This means that game designers can include a variety of breaks in their design without undermining flow states. Our breaks were implemented in a predictable and rigid way, where a player who was paying at least some attention would likely catch on to the pattern. This predictability did not affect how players felt about the game, despite this possibly being an annoyance or frustration. So even if designers implement breaks in a predictable or rigid way, players' flow will not be undermined. It is possible that implementing breaks that occur more naturally or in a less obvious way could improve player engagement and flow, but more study in this area would be needed.

6.6 Professional and Recreational Game Players

Games are becoming more popular everyday, with forecasts predicting 2.9 billion video game players globally by the end of 2021 [98]. A wider variety of people are playing games, with differing skill levels and investment in games. Making sure players are remaining engaged is crucial, in which skill development plays a significant role. Games as a form of entertainment and as a professional career have also grown substantially in the past few years, with the live streaming audience expected to grow globally to 920.3 million by 2024 [1]. As more people choose to take these career paths, players will need to improve their skills constantly in order to remain competitive. Knowing that spaced practice does have benefits for player performance, there are also several implications for both professional and recreational video game players.

For esports players, training for several hours a day may not be the best approach. Taking scheduled consistent breaks during practice could increase skill and lead to better performance during official matches. For online streamers that focus on overcoming challenges or displaying a specific skill, taking breaks during gameplay could lead to better performances during streams. For online streamers who focus on entertainment, spaced practice can also be beneficial. Taking breaks could lead to more entertaining streams provided they took the opportunity to engage with the spectators during the break, while getting some performance benefits as well. This could be particularly useful if the streamer is having difficulty in a particular section and is causing the stream to become less entertaining. For recreational gamers, getting stuck on a difficult part of a game is fairly common. This can lead to frustration, which can cause the player to quit the game. Depending on the level of frustration, the player may become burned out on a game and decide they no longer want to play a game, despite enjoying it up to that point. Stopping to take a break during a difficult gameplay section could help in beating that part of the game and reduce frustration.

6.7 Future Research Considerations

Finally, this does reveal some additional considerations researchers should take into account when running studies and experiments. Researchers should be mindful of performance increases during experiments that involve breaks or pauses—particularly if they are investigating phenomena related to flow, challenge or skill (particularly in experiment designs that cannot be fully counterbalanced). While the activities during the pauses and breaks themselves will not influence the results in the areas of flow or skill, players will likely get a boost in performance just from the breaks themselves.

Alternatively, if researchers have players constantly playing a game with no breaks, this could also alter studies that are investigating other aspects of performance or skill. Keeping in mind how spaced practice and continuous practice works, it would be beneficial for researchers to keep in mind the effects when it comes to games, to ensure they get clear results and improve the ecological validity of studies. In addition, while our different break types did not affect player performance significantly, it was limited to our specific framework, game genre and choice of break. While we tried to be as encompassing as possible, different break types could still affect some aspects of spaced practice in other video games. Keeping this in mind when designing studies that do involve the play pausing or switching activities would likely be beneficial as well.

6.8 Limitations and Future Work

Our study used a bespoke platformer, which allowed us to precisely control the interaction and measurement of expertise. While platformers are popular and familiar, future study is needed to replicate our results in other genres. Our platformer itself is not entirely generalizable to all other platformers: whereas most platformers involve a running and jumping mechanic, they will not have the same physics mechanics as our game. Creating bespoke games for research has a variety of advantages, including allowing for greater experimental control. Although our game was designed to resemble commercial off-the-shelf 2D platformers, it may be that our results do not generalize to platformers and other games produced by professional studios. Future work could explore more game genres with a variety of game objectives to determine the effects of spaced practice and task switching within video games more generally.

Second, the goal to complete as many laps within a certain time frame (as opposed to finishing a level as quickly as possible) may have influenced results. There are many different skills players use when playing games, applied to a variety of objectives, goals and tasks. We plan to expand on our study in future by giving players other goals and objectives, and adding different metrics for measuring performance, in order to test whether goals such as collecting certain items, beating a certain number of enemies, or getting to a certain place could be affected by different break activities.

Third, although we considered a range of break activities, our game could have instead made use of several different breaks. We chose to design breaks that were embedded in a framework (Similarity and Intensity) and made sense within the game's design. However, within our framework we could have made different choices. For lower intensity, breaks such as loading screens, inventory management, perk selections, multiplayer lobbies, or microtransaction menus could have been used. For our higher-intensity breaks, we could have used on-rails shooting sections or timed hacking mini-games. And within the varying intensity, we could have adjusted the similarity of the tasks to the main gameplay task. Future work should explore these and other break designs, both in terms of the spaced practice effect as well as effects on player experience. Players may find certain activities more fun or more tedious, and this could determine how long the breaks feel to the player, which could lead to differences in engagement. Future work could explore how similar to the game a break task can be before the benefits of spaced practice are lost.

Finally, to increase internal validity, our breaks occurred in a predictable manner. Few games have scheduled breaks—most breaks come at either the player's control [2] or through game progression [37, 91]. Players also only had one specific break task, whereas most games will have players engage with different break tasks. Our breaks were also explicitly presented to the player; they knew the breaks would be coming and it was obvious when they were performing break tasks. Whether or not the player knows they are taking a break may affect performance and subjective experience. Further research could explore varying break lengths within games, and even changing the break length during gameplay, to adapt to player skill in real time and improve the learning curve.

In addition to the limitations and future works already discussed, there are other areas of research that could look at spaced practice in games. Research into implementation would provide more guidance for game developers and designers when making games. Predictability of breaks could provide insight into how letting the player know a break is coming can affect performance. Player-induced breaks may alter how the players experience breaks and impact how they perform. Inversely, forcing breaks that occur due to players action within the game, such as a death, could also provide insight as to how players experience breaks. Finally having the players perform different break tasks within the same game would add more evidence for a change being as good as a rest. It would be likely that having different break types within the same game would not influence player performance based on our findings, however, we do not know this for certain. Players in our game only experienced one break type each, so having alternating or random break types may affect performance in a way we have not considered. This would be important to research, as most games include a variety of activities and knowing how that affects performance would be vital in designing a game that has a lot of breaks, such as an RPG.

7 Conclusion

7.1 Summary

Skill development in video games is of high importance to both players and designers. Based on prior work using spaced-practice techniques appeared to be a viable option for designers to create games that facilitate skill acquisition for players. While much is known about spaced practice in non-game contexts, there is limited knowledge about the effect of spaced practice in game contexts—especially in games that require the development of multiple skills.

To address this gap, we carried out two experiments to determine whether or not spaced practice benefits performance in complex video games, and how different in-game break activities affect player performance and experience. In order to address this, we created a bespoke 2D platformer that involved multiple skills for the player to use on a repeating obstacle course. Players attempted to complete as many levels as possible in a 20-minute span, broken up into 5-minute gameplay segments, with either a 2 minute break or 3-second non-break in between each segment. Each break was a blank screen with a timer counting down, allowing the player to use their computer freely.

The first study provided our first of three valuable contributions: first, we show that the spaced practice effect works in a complex game. Players in our spaced practice group performed better than those in our continuous practice group in both main task and retention task. This means that designers can implement spaced practice into games with more confidence that its benefits will work.

After determining if spaced practice worked in our game, we wondered if changes of gameplay, rather than rests, as breaks would impact player performance and experience. We created a design framework to categorize different break types, based on similarity and intensity. This allowed us to implement four different break types, with high and low degrees of similarity and intensity, into our platformer. We gathered data from four more groups of participants, where each group experienced one of our four break types, to determine if a change would influence player performance and which of our four breaks would have the greatest impact.

Our second major contribution shows that the type of break activity does not inhibit the spaced practice effect. All four groups performed similarly to each other, performed similarly to the spaced practice group from study one, and appeared to outperform the continuous practice group from Study 1. This means that designers can implement various break types with a ranging degree of similarity and intensity, with minimal concern for how it affects the player's performance.

Finally, in our third major contribution, we provide evidence to suggest that short breaks do not interrupt flow states. So this means, not only do different break types not affect player performance, but the player experience also seems to be unaffected, allowing for more freedom in break implementation. Our work provides useful information for players who want to improve their video game skills, valuable insight into potential future research in the areas of flow, skill development, and spaced practice, and practical considerations for game designers who want to make better play experiences.

7.2 Closing Thoughts

Games are more popular than ever, with new found industries in games beyond designers and developers. Professional game players, like esports athletes and streamers, need to be able to gain skill faster in order to have successful careers. In addition, with games becoming more shared and continuing to have a competitive nature, game designers for commercial games are incentivized to create games that facilitate skill development for players.

This work provides three contributions that are useful to designers. It provides more evidence for the use of spaced practice in games, which can be more confidently used by designers for player skill development. This work also provides designer knowledge on how they can use spaced practice exactly and how they can use breaks. By implementing in-game activities, such as menu navigation, mini games and cutscenes, in a way that utilizes spaced practice, designers can use its effects to improve their games. Our results also provide some general knowledge on the nature of spaced practice as a phenomenon. Finally, game designers also have evidence that spaced practice and breaks do not affect the player experience, so they know there is no trade off in player skill gains and experience when it comes to spaced practice. They will create a gameplay experience that allows players to improve faster in a controlled way without damaging the gameplay experience.

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Appendix

PausePlay

Introduction → **Consent** → MTurk ID → Questionnaire (3) → Game → Questionnaire (3) → End

Before proceeding, please read the following. You must give your consent to continue.

Title: The Effects of Spaced Practice on Experience and Performance in a Digital Game
Researcher(s):

- Brandon Piller, Masters Student, Department of Computer Science, University of Saskatchewan, 306-966-2327 brandon.piller@usask.ca
- Colby Johanson, Ph.D. Student, Department of Computer Science, University of Saskatchewan, 306-966-2327, colby.johanson@usask.ca
- Dr. Regan Mandryk, Professor, Department of Computer Science, University of Saskatchewan, 306-966-4888, regan@usask.ca
- Dr. Carl Gutwin, Professor, Department of Computer Science, University of Saskatchewan, 306-966-8646, gutwin@usask.ca

Purpose(s) and Objective(s) of the Research: The purpose of this study is to understand how spaced practice sessions impact player experience performance in a digital game.
Procedures:

- You will complete questionnaires asking questions about yourself, and your experience with games (about 10 minutes).
- You will play a digital game for 26 minutes.
- You will then complete questionnaires relating to your experience playing the game.

Funded by: The Natural Sciences and Engineering Research Council of Canada (NSERC).
Potential Risks and Benefits: There are no known or anticipated risks to you by participating in this research. Your participation will help us better understand how spacing out practice sessions impacts play experience and learning.
Confidentiality:

- Confidentiality will be maintained throughout the study. The entire process and data will be anonymized. Data will only be presented in the aggregate and any individual user comments will be anonymized prior to presentation in academic venues.
- Only the principal researcher and their research assistants will have access to the data to ensure that your confidentiality is protected.
- Storage of Data
  - Data (including questionnaire responses and logs of computer use) will be stored on a secure password-protected server for 5 years after data collection.
  - After 5 years, the data will be destroyed. Digital data will be wiped from hard disks beyond any possibility for data recovery.

Right to Withdraw:

- Your participation is voluntary. You may withdraw from the research project for any reason, at any time without explanation.
- Should you wish to withdraw, you may do so at any point, and we will not use your data; we will destroy all records of your data.
- Withdrawal requests can be made by contacting us through the Mechanical Turk website.
- Your right to withdraw data from the study applies until May 1, 2020. After this date, it is possible that some form of research dissemination will have already occurred and it may not be possible to withdraw your data.

Follow up: To obtain results from the study, please contact Brandon Piller (brandon.piller@usask.ca).
Questions or Concerns:

- Any questions you many have regarding consent can be sent to us by contacting us through the Mechanical Turk website or by sending an email to any of the contact emails listed in this consent form.
- This research project has been approved on ethical grounds by the University of Saskatchewan Research Ethics Board. Any questions regarding your rights as a participant may be addressed to that committee through the Research Ethics Office ethics.office@usask.ca (306) 966-2975. Out of town participants may call toll free (888) 966-2975.

Copies:

- If you would like to keep a copy of this consent form for your records, simply right-click this web page, click "Save Page As..." and follow the prompts provided by your web browser.

By clicking the consent button below, you are indicating that you...

- Have read and understand the description provided.
- Have had an opportunity to ask questions and your questions have been answered.
- Consent to participate in the research project.

1 ACS Questionnaire

PausePlay

Introduction → Consent → MTurk ID → **Questionnaire (2 of 3)** → Game → Questionnaire (3) → End

Read each item carefully. Using the provided scale, please indicate your agreement with each item.

	Almost never	Sometimes	Often	Always
After being interrupted or distracted, I can easily shift my attention back to what I was doing before.	○	○	○	○
I have a hard time concentrating when I'm excited about something.	○	○	○	○
It takes me a while to get really involved in a new task	○	○	○	○
It is easy for me to read or write while I'm also talking on the phone.	○	○	○	○
When concentrating I ignore feelings of hunger or thirst.	○	○	○	○
When I am reading or studying, I am easily distracted if there are people talking in the same room.	○	○	○	○
I can become interested in a new topic very quickly when I need to.	○	○	○	○
I can quickly switch from one task to another.	○	○	○	○
When a distracting thought comes to mind, it is easy for me to shift my attention away from it.	○	○	○	○
When I need to concentrate and solve a problem, I have trouble focusing my attention	○	○	○	○
It is easy for me to alternate between two different tasks.	○	○	○	○
It is difficult for me to coordinate my attention between the listening and writing required when taking notes during lectures.	○	○	○	○
It's very hard for me to concentrate on a difficult task when there are noises around.	○	○	○	○
It is hard for me to break from one way of thinking about something and look at it from another point of view.	○	○	○	○
I have a hard time coming up with new ideas quickly.	○	○	○	○
When trying to focus my attention on something, I have difficulty blocking out distracting thoughts.	○	○	○	○
When concentrating, I can focus my attention so that I become unaware of what's going on in the room around me.	○	○	○	○
My concentration is going even if				

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2 SOQ Questionnaire

PausePlay

Introduction → Consent → MTurk ID → **Questionnaire (3 of 3)** → Game → Questionnaire (3) → End

Read each item carefully. Using the provided scale, please indicate your agreement with each item.

	Strongly disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Strongly agree
I enjoy competing against others.	○	○	○	○	○
Winning is important.	○	○	○	○	○
My goal is to be the best gamer possible.	○	○	○	○	○
I perform my best when I am competing against an opponent.	○	○	○	○	○
Reaching personal performance goals is very important to me.	○	○	○	○	○
The best test of my ability is competing against others.	○	○	○	○	○
I have the most fun when I win.	○	○	○	○	○
I am a competitive person.	○	○	○	○	○
I work hard to be successful in games.	○	○	○	○	○
I try my hardest to win.	○	○	○	○	○
I look forward to the opportunity to test my skills in competition.	○	○	○	○	○
I look forward to competing.	○	○	○	○	○
I set goals for myself when I compete.	○	○	○	○	○
Losing upsets me.	○	○	○	○	○
I want to be successful in games.	○	○	○	○	○
I thrive on competition.	○	○	○	○	○
Performing to the best of my ability is very important to me.	○	○	○	○	○
I am a determined competitor.	○	○	○	○	○
I hate to lose.	○	○	○	○	○
Scoring more points than my opponent is very important to me.	○	○	○	○	○
I try hardest when I have a specific goal.	○	○	○	○	○
I am most competitive when I try to achieve personal goals.	○	○	○	○	○
I want to be the best every time I compete.	○	○	○	○	○
The only time I am satisfied is when I win.	○	○	○	○	○
The best way to determine my ability is to set a goal and try to reach it.	○	○	○	○	○

Continue

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3 FKS Questionnaire

PausePlay

Introduction → Consent → MTurk ID → Questionnaire (3) → Game → **Questionnaire (1 of 3)** → End

Think back to when you were playing the game. For each statement, indicate how much it describes the way you felt at that time.

	Not at all						Very much
My thoughts/activities run fluidly and smoothly.	○	○	○	○	○	○	○
I have no difficulty concentrating.	○	○	○	○	○	○	○
My mind is completely clear.	○	○	○	○	○	○	○
I won't make any mistake here.	○	○	○	○	○	○	○
I know what I have to do each step of the way.	○	○	○	○	○	○	○
I am worried about failing.	○	○	○	○	○	○	○
I feel that I have everything under control.	○	○	○	○	○	○	○
The right thoughts/movements occur of their own accord.	○	○	○	○	○	○	○
I am totally absorbed in what I am doing.	○	○	○	○	○	○	○
Something important to me is at stake here.	○	○	○	○	○	○	○
I feel just the right amount of challenge.	○	○	○	○	○	○	○
I don't notice time passing.	○	○	○	○	○	○	○
I am completely lost in thought.	○	○	○	○	○	○	○

Continue

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4 IMI Questionnaire

6/10/2021 PausePlay

PausePlay

Introduction → Consent → MTurk ID → Questionnaire (3) → Game → **Questionnaire (2 of 3)** → End

Reflect on your play experiences and rate your agreement with the following statements.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I felt pressured while playing the game.	○	○	○	○	○
I didn't try very hard at playing the game.	○	○	○	○	○
I am pretty skilled at the game.	○	○	○	○	○
It was important to me to do well at this game.	○	○	○	○	○
I was very relaxed while playing the game.	○	○	○	○	○
I enjoyed this game very much.	○	○	○	○	○
I was anxious while playing the game.	○	○	○	○	○
I tried very hard while playing the game.	○	○	○	○	○
While playing the game, I was thinking about how much I enjoyed it.	○	○	○	○	○
I couldn't play this game very well.	○	○	○	○	○
After playing the game for a while, I felt pretty competent.	○	○	○	○	○
I am satisfied with my performance at this game.	○	○	○	○	○
Playing the game was fun.	○	○	○	○	○
I think I am pretty good at this game.	○	○	○	○	○
This game did not hold my attention.	○	○	○	○	○
I felt tense while playing the game.	○	○	○	○	○
I put a lot of effort into this game.	○	○	○	○	○
I would describe this game as very interesting.	○	○	○	○	○

Continue

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5 Feedback Questionnaire

6/10/2021 PausePlay

PausePlay

Introduction → Consent → MTurk ID → Questionnaire (3) → Game → **Questionnaire (3 of 3)** → End

Please answer the following questions.

Did you experience any technical issues?

Feedback

Continue

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6 Demographics Questionnaire

6/10/2021 PausePlay

PausePlay

Introduction → Consent → MTurk ID → **Questionnaire (1 of 3)** → Game → Questionnaire (3) → End

Please answer the following questions.

What is your gender?

Select an option

What is your age?

How much do you self-identify as a gamer on the following scale?

Not at all Gamer

How familiar are you with side-scrolling platform games?

Not at all Very Familiar

How often (on average) do you play games?

Select an option

If you have played games more often in the past, how often were you playing at peak times?

Select an option

Do you tend to play 2D or 3D games?

- Mostly 3D
- Mostly 3D, some 2D
- An equal amount of 2D and 3D
- Mostly 2D, some 3D
- Mostly 2D
- I don't play games

What genres do you enjoy playing? (Leave blank if none)

- Action
- Platform games
- First Person Shooter (FPS)
- Beat 'em up
- Adventure
- Role Playing Games (RPG)
- Massively Multiplayer Role Playing Games (MMORPG)
- Multiplayer Online Battle Arena Games (MOBA)

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