Is a Change as Good as a Rest? Comparing Break Types for Spaced Practice in a Platformer Game

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ABSTRACT

The development of skill in games is of interest to players and designers. Spaced practice in games, i.e., adding breaks to core gameplay, has been shown to improve performance over playing continuously; however, it is unclear if the benefits of spaced practice apply in complex games that combine several skills and elements. Further, many break-like activities are already present in games (e.g., cutscenes, mini-games, leaderboards, loading screens) and we do not know whether engaging with these as breaks reduces the benefits of spaced practice. We built a custom 2D platform game in which players wall-jump, swing, and double-jump through an obstacle course and used it 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. We show 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.

CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**; **HCI theory, concepts and models**;

KEYWORDS

Spaced Practice; Video Games; Task Switching; Design

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1 INTRODUCTION

Between the meteoric rise of esports and the continued popularity of competitive gaming, the need to understand how players develop in-game skills has become increasingly important. The development of skill in games is a topic of great interest to both players and game designers: players want to get better, and designers want to understand and support player progress. These goals align, in part, because the facilitation of skill development is associated with a variety of positive player experiences, such as self perceived competence [46] and flow states [15]. In effect, to facilitate positive player experiences, skill acquisition is important.

One technique that can improve several kinds of skill is the idea of spaced practice [18, 36, 54], which suggests that taking breaks between task sessions leads to improved acquisition of a skill and better immediate performance. However, people tend to have a preference for continuous practice [70], and this preference has been observed in game contexts as well [33]. Beyond player preferences, there are valid concerns about breaks interfering with the intense focus and concentration that is present during flow states.

Although studies have shown that spaced practice works in game environments [33, 41, 56], there is still little information available to aid game designers in harnessing this effect for players. First, we do not know if the benefits of spaced practice apply to every game. The studies demonstrating this effect in games have used relatively simple games, including a variation of *Pong* [8, 41], a variation of *Asteroids* [17, 56], and a clone of *Super Hexagon* [13, 33]. Previous research has shown that spaced practice is not as effective for complex skills [18, 43, 73], so it may be that the technique does not apply in cases where the game involves multiple skills to learn. Second, little is known about what players should do during breaks. Break-like activities are already present in games (e.g., cutscenes, mini-games, inventory management, player statistics presentations, or free play environments) and compared to an explicit rest, they can keep players engaged with the game while providing a break from the primary game task. Although these options exist, it is not clear whether they will interfere with the underlying mechanism of spaced practice, for example, by being too demanding or too similar to the primary game task.

To address these two concerns, we built a bespoke platformer game that was more complex than games used in prior research on spaced practice [17, 33, 41, 56]. Our game required multiple skills, including running, jumping, wall jumping, swinging via a grappling hook, and remembering the game map. The use of these skills by the player involves a number of distinct actions that must be coordinated, which increases game complexity. Using this game, we conducted two experiments. 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). In Experiment Two, we asked whether the type of break activity affects the benefits of spaced practice. We had all participants play four 5-minute gameplay segments with 2-minute breaks and compared various in-game break activities. We designed breaks that differed in terms of 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); we designed low and high levels of each factor, resulting in four break types (a dialogue with an NPC, a maze mini-game, and a grapple mini-game that could be either fast or slow). Both experiments included a retention test, carried out one week later, in order to determine if performance differences lasted beyond the immediate play session.

Our two studies provided several new results about the use of breaks for skill development in games:

- Spaced practice was superior to continuous practice for games with multiple skills, and the benefits persisted over time.
- The benefits of spaced practice were not reduced by engaging in different in-game break activities.
- The efficacy of the break was not affected by intensity or similarity of the break relative to the game itself.
- The subjective experience of the game was not affected by the break.

Our work provides three main contributions. First, we show that spaced practice significantly improves learning and skill development in a relatively complex game involving multiple skills; therefore, designers can make use of this principle in a wider variety of games. Second, we show that spaced practice is effective across several types of ecologically valid break activities varying in intensity and similarity to the game task; this means that designers have substantial freedom to create break activities that suit their game, without losing the benefits of spaced practice. Third, we show that the use of short breaks does does not interfere with flow states; this means that designers can make use of spaced practice without fear of undermining flow.

2 RELATED WORK

We present factors that influence learning, including spaced practice, task switching, and skill acquisition in games.

2.1 Spaced Practice

Spaced practice refers to scheduled periods of breaks in between periods of activity during a training session [54]. Spaced practice is often contrasted with continuous practice that uses a minimal break or no break at all [54]. Compared to continuous practice, spaced practice typically results in improvements to immediate performance as well as performance in retention tests [18, 36]. There is considerable evidence to support the effectiveness of spaced practice in tasks ranging from learning lists of nonsense syllables [22], tracing objects through a mirror [58], typing [10], fear desensitization [47], and surgical skills training [38]. Meta-reviews of spaced practice studies show that it is a strong effect [18, 36], although the improvements vary with task type [18, 37], current stage of learning [35, 61], and retention period [18]. For example, some studies suggest that complex tasks appear to benefit less [18] – such as learning a musical sequence on the piano [73] or learning specific math problems [43].

2.1.1 Spaced Practice and Games. Most research on spaced practice in games has focused on serious games in the context of education and verbal learning (e.g., [23, 52, 53]). The few studies that do focus on in-game skills support the idea that spaced practice has benefits [33, 41, 56]. The earliest study [41] had participants play a simple *Pong*-inspired game on a computer, involving 10 rounds of gameplay with either no break or a 2-minute break (during these breaks, participants were instructed to read a newspaper). The study found that spaced practice resulted in better performance over continuous practice. Another study had participants play a game called *Space Fortress* [17], a variation on *Asteroids* [9] with additional strategic elements. The experiment had participants play the game for 10 hours, spread over either 2 days or 10 days [56], with a retention task one week later. Results showed that participants who trained over 10 days outperformed participants who trained over 2 days.

A more recent study provides further evidence that spaced practice works in video games [33]. Participants played a clone of *Super Hexagon* [13] for four five-minute sessions with one of five break intervals (3 seconds, 2 minutes, 5 minutes, 10 minutes, and 1 day). Participants were instructed to use their computer in any way they wanted during breaks. Spaced practice resulted in improvements over continuous practice, and all spacing intervals performed equally well. Of these three studies, only one put constraints on what participants were to do with their break.

2.1.2 Why Spaced Practice Works. Performance improvements are largely due to decreases in reaction time, improvements in selecting responses to stimuli, and reduced errors in execution [45, 54, 64]. Progress in this ability is described in terms of the learner transitioning [60] to later stages of skill development [25, 35]. Spaced practice has been shown to assist this process [61], 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) [6]. 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 [14, 59]. Additionally, taking a break from a task forces retrieval of the relevant memory traces when returning to the task, reinforcing them [49, 70].

Spaced practice may also work because of fatigue effects. It was once thought that benefits were driven by muscular fatigue [5, 21]; however, retention tests provided after a break showed that improvements often persisted (e.g., [11]). Although fatigue is not solely responsible for the differences, it can still play a role [70]. Due to cognitive fatigue, participants may not be able to give the task their complete attention for the entirety of the study [3, 70] and this decreased attention can negatively affect performance and learning.

2.2 Task Switching

While research on spaced practice provides little guidance on what players should do during breaks, we do know a lot about task switching, including how it affects performance and learning. Past work indicates that switching between certain tasks can degrade performance [50, 54] due to making more errors [7]. How much performance degrades is related to the familiarity of the task. Switching from a familiar to unfamiliar task has a greater cost than switching from an unfamiliar to a familiar task [50]. Performance drops can be minimized by allowing the participant to prepare for the switch, although it will not completely remove the cost [42]. 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 [54].

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 [55].

2.3 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 [2]. In functional terms, the player's ease of control increases, and they become more capable of meeting the game's challenges [46, 51]. In psychosocial terms, players have increased subjective feelings of competence or mastery [46]. 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 [26, 44].

Flow is an 'optimal experience' associated with task enjoyment [57]. 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 [44]. Flow theory has been broadly applied in the context of digital games, and many commercially successful games are considered to promote flow states [28]. 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 [26, 44]. Adding clear goals, immediate feedback [63], and increasing a game's challenge [30, 34, 62, 72] 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, 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, such that it is better matched with the relative skill of the player [74].

3 A DESIGN FRAMEWORK FOR IN-GAME BREAKS

Aside from the suggestion that the breaks need to be more 'restful' than the task [54], 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. 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 [4]. There are many examples of breaks in commercial games, such as cutscenes, menus, loading screens, and mini-games. Some of these breaks can be very similar to the main game in context and gameplay (e.g., mini-games), while others can be very different (e.g., loading screens). In-game breaks present themselves in many different ways, but for our purposes we needed a way to describe break commonalities and differences. 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).

3.1 Similarity

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 significant game segment, as a small reward for the player [29]. *Half-Life* [65] 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 (i.e., they could walk around and interact with the game world as they normally would).

Mini-games can vary widely in terms of their similarity to the main game. In *Bioshock* [1] 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.

Another example of a break that has low similarity is the first-person shooter *Counter-Strike* [66]. 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.

3.2 Intensity

Breaks can also vary in the *intensity* of their activity's mechanics. Break activities typically reduce intensity. For example, when players are defeated by a boss in *Dark Souls* [27], 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, but they do serve to capture a player's attention and break up any monotony in the game. For example, in *Left 4 Dead* [67], players spend most of their time in levels searching for supplies and routinely shooting zombies as they try survive until the end of the level. Randomly and infrequently, the game will spawn boss zombies that require coordination from all players to be defeated.

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. Mini-games may or may not be as intense as the main game. For example, in *Donkey Kong Country* [48], 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.

4 METHODS

We report on two experiments with different aims. Our first goal is to determine whether the spaced practice effect works in complex video games involving several skills and coordinated actions. Our second goal is to determine how different types of activities used for in-game breaks affect the value of spaced practice in a complex game.

In the following sections, we discuss the design of our game, the different break types, our experiment designs, how we measured the efficacy of spaced practice, and how we measured effects on player experience.

4.1 Designing a Digital Game for the Study

To investigate the potential of spaced practice in a more complex game, we designed and developed a game that could be played by individuals with basic gaming experience but that involved developing proficiency with multiple skills. To investigate the effects of changing the break activity, the game also had to seamlessly support various break types that felt natural within the gameplay context.

Recent work on spaced practice in games [33] used a clone of *Super Hexagon* [13], 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.

Based on these guidelines, we designed and developed a 2D side-scrolling platformer inspired by *SpeedRunners* [19] (Figure 1). In our game, the player controls a lumberjack avatar with the left and right arrow keys or the A and D keys, and traverses a set of obstacles in a circular course (i.e., a lap), repeating the course as many times as possible within each 5-minute play session. To complete a lap, players run, jump, wall jump, and swing using a grappling hook; the grapple was included as an advanced skill that is easy to learn but hard to master. The game automatically targeted nearby grapple points (coloured bright yellow and highlighted red when targeted); when the player pressed the grapple button, the grapple attached to the nearest point and they would start swinging. The player could adjust the length of the grapple and use the movement keys to control the swing. By releasing at the right moment, the player could leap to next ledge or grapple point.

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.

4.2 Break Type and Experiment Factors

We developed our break activities to resemble those found in commercial games while focusing on our two 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: high similarity activities use mechanics from the main game (jumping and grappling), while low similarity use mechanics not used in the game; high intensity activities required interaction and reaction times that were similar to the main game, whereas low intensity tasks involved limited input without the need for quick reactions.

The resulting four break types are shown in Figure 1: a dialogue scene in which the player interacted with a 'mountain man' in a binary-choice conversation about mountains and video games (low intensity/low similarity), a grapple mini-game in which a player used just the grapple mechanic (no jumping or running) to try to swing as high as possible (high intensity/high similarity), a slow-motion version of the grapple mini-game (slow-mo grapple mini-game; low intensity/high similarity), and a maze mini-game in which the player had to use the arrow keys to collect gems within a maze (high intensity/low similarity).

In two experiments, participants played the main game in four 5-minute gameplay segments, with a break between each segment. In Experiment One, we compared spaced practice to continuous practice; in Experiment Two, we looked at how the different break activities affected skill development. In both experiments, we asked participants to also complete a retention task one week after the main study session, to look for persistence of the performance differences. The retention task involved playing the same level from the main experiment, completed in one 5-minute gameplay segment without any break. Details of each experiment design are reported in Sections 5 and 6.

4.3 Measures

In both experiments, we measured performance, player experience, and player trait variables.

Trait variables. Several questionnaires were used to determine traits, i.e., stable variables that describe the participants:

Gaming Expertise. We asked participants about gaming experience with two 100-pt 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?'.

Attentional Control. Because attention could affect the player's ability to improve at the game and maintain performance, we used the Attentional Control Scale (ACS) [16] to measure each participant's attentional control (i.e., their ability to concentrate and explicitly direct attention).

Achievement Orientation. Because highly motivated players may put more effort into improving at the game, we used the Sport Orientation Questionnaire [31] to measure 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).

Dependent Measures. Our experiment included four dependent measures—two for performance and two for subjective experience. Performance was measured during each 5-minute gameplay segment, and subjective experience was measured twice: after the last gameplay segment and one-week later (after the retention task).

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.

Intrinsic Motivation. To investigate potential effects of breaks on intrinsic motivation, the experiment assessed intrinsic motivation through the Intrinsic Motivation Inventory (IMI) [40]. The IMI has previously been used in games research to assess four constructs: enjoyment/interest, effort/importance, perceived competence, and pressure/tension, each of which give valuable insight into player experiences. Each of these constructs (and their cumulative inference of intrinsic motivation) were thought to be pertinent to this investigation of skill acquisition and the player experience.

Flow. To investigate how break type affected flow states, we used the Flow Short Scale (FKS) [71]. The FKS was selected due to its focus on skill; fluency of performance, skill, demand, and fit of demands and skills. In addition to these four constructs, 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.

4.4 Recruitment

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., [12, 33]) when precautions are taken [20, 39].

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 experiments (the tutorial could be completed in as little as 30 seconds). In addition, people were only allowed to participate in either experiment, not both.

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.

5 EXPERIMENT ONE

The goal of Experiment One was to test if the spaced practice effect applies in a more complex game, since previous research has suggested that spaced practice is not effective for some complex tasks (e.g., [43, 73]). We extend the results of Johanson et al. [33] and provide a new contribution about the scope of spaced practice's benefit in the game domain.

Figure 1: the four break types, left to right: Dialogue, Grapple mini-game fast and slow-motion, Maze

Like 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 in which participants were free to use their computer as they wished (note that this experiment did not use the break types described above); the continuous practice group had a 3-second break. Once the break timer expired, an audio cue would play and a continue button would prompt the participant to continue when they were ready. 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.

5.1 Participants

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 API 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 (all $p \geq .185$).

5.2 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 [68]. 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 Flow Scale Short (FKS) and Intrinsic Motivation Inventory (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 [69], 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 [24] (as sphericity estimates >.75).

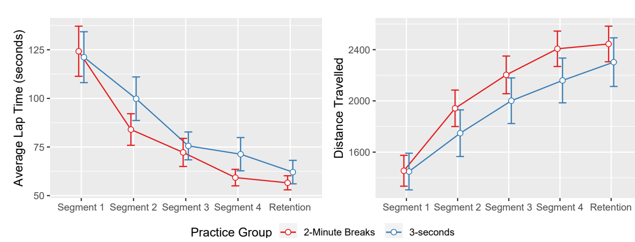

Figure 2: Performance results for Experiment 1. Error bars show standard error.

5.3 Results

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

5.3.1 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 ($F_{1.78,87.3} = 0.05$, $p = .940$, $\eta_p^2 = .001$).

5.3.2 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 ($F_{1,44} = 4.21$, $p = .046$, $\eta_p^2 = .087$).

5.3.3 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 1 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).

5.4 Summary of Results

Experiment One confirmed that spaced practice improved performance in our game over continuous practice, similar to results seen with simpler games in different genres.

6 EXPERIMENT TWO

The goal of Experiment Two was to determine whether different in-game break activities affected the demonstrated benefits of spaced practice. 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 whether 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.

Instead of allowing participants to use their computer freely, as was done in Experiment One based on previous work [33], in Experiment Two, we randomly assigned participants to one of four break conditions, described in Section 4.2. 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-game and maze breaks. Once the 2 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.

6.1 Participants

A total of 226 participants completed Experiment 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.

6.2 Analyses

The analyses used for Experiment 2 were very similar to those used for Experiment 1. For performance, we once again used a repeated measures analysis of covariance (RM-ANCOVA) for each of our two dependent measures of performance—average lap time and total distance travelled. Segment (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

		Flow		Worry		Pressure		Interest-Enjoyment		Effort		Competence	
		Training	Retention	Training	Retention	Training	Retention	Training	Retention	Training	Retention	Training	Retention
Experiment 1	2-minute break	5.08 ± 0.80	4.96 ± 0.99	3.51 ± 1.52	3.48 ± 1.44	2.77 ± 1.05	2.52 ± 0.90	3.54 ± 0.81	3.55 ± 0.85	4.15 ± 0.58	3.94 ± 0.84	3.83 ± 0.79	3.85 ± 0.72
	3-second break	4.90 ± 0.91	5.08 ± 0.88	3.82 ± 1.50	3.97 ± 1.18	2.89 ± 1.11	2.79 ± 1.17	3.62 ± 0.99	3.89 ± 0.77	4.29 ± 0.67	4.07 ± 0.81	3.71 ± 0.82	3.83 ± 0.72
Experiment 2	Low Intensity	4.92 ± 1.09	5.11 ± 1.01	3.45 ± 1.23	3.60 ± 1.10	2.80 ± 1.07	2.67 ± 1.07	3.56 ± 0.96	3.78 ± 0.84	4.25 ± 0.67	4.26 ± 0.60	3.78 ± 0.81	3.85 ± 0.83
	High Intensity	4.84 ± 1.15	5.01 ± 0.96	3.26 ± 1.50	3.31 ± 1.36	2.78 ± 1.03	2.53 ± 1.01	3.37 ± 1.08	3.49 ± 0.95	4.14 ± 0.71	4.09 ± 0.69	3.49 ± 0.94	3.84 ± 0.77
	Low Similarity	4.84 ± 1.14	5.09 ± 0.97	3.46 ± 1.39	3.57 ± 1.26	2.81 ± 1.08	2.53 ± 1.04	3.43 ± 1.03	3.72 ± 0.87	4.17 ± 0.76	4.22 ± 0.68	3.63 ± 0.86	3.95 ± 0.68
	High Similarity	4.91 ± 1.11	5.02 ± 1.00	3.25 ± 1.36	3.32 ± 1.25	2.77 ± 1.01	2.66 ± 1.03	3.49 ± 1.03	3.52 ± 0.95	4.22 ± 0.61	4.12 ± 0.62	3.63 ± 0.93	3.74 ± 0.88

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

distance travelled, the assumption of sphericity was violated, so Huynh-Feld correction was used [24].

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 Flow Scale Short (FKS) and Intrinsic Motivation Inventory (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 experiment two, data were analyzed in the same way as experiment one.

For all tests, covariates were selected on the basis of whether they correlated with our dependent measures. All covariates were mean-centred [69], 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.

		Intensity			Similarity			Similarity*Intensity		
		F	p	η_p^2	F	p	η_p^2	F	p	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	0.05	.474	.004	1.01	.318	.008	0.00	.956	.000
	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 2: 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).

6.3 Results

We first present results for performance, followed by measures of player experience. See Table 2 for statistics and descriptive statistics and Figure 3 for results.

6.3.1 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 Experiment One. As these were two separate experiments with different samples of participants, we do not provide statistical comparisons between these six groups; however, Figure 4 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 Experiment One 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 Experiment Two.

6.3.2 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 ($F_{2,260} = 3.97$, $p = .020$, $\eta_p^2 = .030$).

6.3.3 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 2). 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 2).

6.3.4 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 2). We also found no significant interactions between Intensity and Similarity. See Table 1 for descriptive statistics.

7 DISCUSSION

In the following sections we address our main research questions and then consider possible explanations for results, implications for game design, limitations, and future work.

7.1 Research Questions

Does Spaced Practice Work in More Complex Games? Our results indicate that spaced practice improves skill development in a 2D side-scrolling platformer that required multiple coordinated skills.

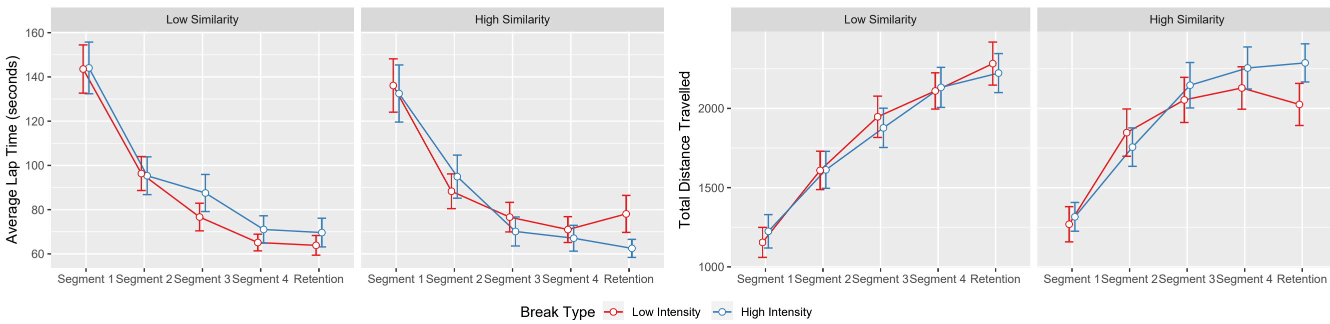

Figure 3: Performance results for Experiment 2. Error bars show standard error.

Figure 4: Performance deltas from Segment 1 for all groups from Experiment 1 and 2.

Both experiments showed that spaced practice resulted in improvements over time, and Experiment One showed that taking breaks led to significant gains. 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. 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.

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. 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 4), but the differences were not significant, suggesting that if there are differences between different levels of similarity and intensity, they are not substantial.

7.2 Explanation of Results

There are several possible reasons that underlie our findings:

7.2.1 Why Were the Different Breaks Equally Effective? 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 [54]. 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.

7.2.2 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 [42], noting that the important factor might actually be giving time for participants to prepare for the switch. A study by Gillie and Broadbent [32] 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 [7], 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.

7.2.3 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 [54], 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 [70] 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.

7.2.4 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.

7.2.5 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.

7.3 Implications for Design

Our results have several implications for game designers. First is further evidence that the spaced practice effect works in video games. 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. 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.

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. 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.

The third finding is that flow is not undermined by the presence of a 2-minute break, and is 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.

Finally, 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.

There are also several implications for both professional and recreational video game players. For professional video game players, such as esport players or online video game streamers, training continuously for several hours a day may not be the best approach. For professionals, taking breaks during practice could increase skill and lead to better performance in critical situations; for recreational players, stopping to take a break during a difficult gameplay section could help in beating that part of the game and reducing frustration.

Finally, 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).

7.4 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.

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. 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 loading screens, inventory management, perk selections, multiplayer lobbies, or microtransaction menus. For our higher-intensity breaks, we could have used on-rails shooting sections or timed hacking mini-games. 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 [1] or through game progression [27, 65]. 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. Other areas of research could look at predictability of breaks, player-induced breaks, or having the players perform different break tasks within the same game.

8 CONCLUSION

Skill development in video games is of high importance to both players and designers. By using spaced-practice techniques, designers can 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. Our work provides three valuable contributions: first, we show that the spaced practice effect works in a complex game; second, we show that the type of break activity does not inhibit the spaced practice effect; and third, we provide evidence to suggest short breaks do not interrupt flow states. 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.

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