Adaptation in Digital Games: The Effect of Challenge Adjustment on Player Performance and Experience

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ABSTRACT
Good gaming experiences hinge on players being able to have a balance between challenge and skill. However, achieving that balance is challenging, so dynamic difficulty adjustment offers the opportunity to provide better gaming experiences through adapting the challenge in the game to suit an individual's capabilities. The risk though is that in adapting the difficulty, players do not get a true sense of challenge, but rather some tailored, perhaps watered down experience. In this note, we report on a study, in which we used time manipulation as a method of simple adaptation in order to explore its effect on player experience (PX) and performance. Volunteers played a game in which the timer was adjusted based on their performance in the game, however they were not aware of the feature. The results showed that players in the experimental group found the game more immersive. This provides empirical support that dynamic difficulty adjustment could be used to improve the PX.

Author Keywords
Digital games; Immersion; Player performance; Time manipulation; Adaptation.

ACM Classification Keywords
H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

INTRODUCTION
Digital games rely on techniques that are often lumped together as artificial intelligence (AI) as a way to provide players with a suitable challenge. Though the AI may respond appropriately to generate the action in a game by providing a challenge, the level of challenge is often dictated at design time by setting specific attributes of the in-game AI. This means that the challenge may be too high for some players, leading to frustration [26] and reduced enjoyment [17], or even a decision to no longer play. Adaptive AI is a well-recognised concept in gaming communities, which refers to the ability of a digital game to match player's actions in an intelligent and appropriate manner [23]. This involves modifying the challenge of the game based on player's skills, typically modifying behaviour of the non-player characters with accordance to the player's behaviour. The concept is being widely explored in digital game industry to ensure playability for a wider range of players – many algorithms and models are being developed in order to learn from the player [5, 12].

Changing the level of challenge in a game makes it possible to balance game play to the skills of the player, potentially providing better gaming experiences and prolonging the period of play. In the most extreme case of PX, a perfect match of skills and challenge is a major constituent of flow [9]. Matching in-game challenge to the players' skill set has been widely discussed in PX literature, suggesting that it is an important factor for keeping the player satisfied [7, 24]. However, this idea is only backed up by theoretical literature about flow and its implications in various media [22], without much empirical evidence for such claims.

Any changes to a game brings about potential threats to the PX. Some games are all about the high level of challenge – Super Meat Boy [18] is a notorious example. Reducing the level of challenge in such games could in principle destroy the point of the game. And even in games which are not all about the high challenge – a reduced challenge, however carefully reduced, may simply not be of consequence, because games are after all about being challenged. Interestingly, there is little research into the actual effects of difficulty adaptation on PX. In this note, we begin to address this by reporting on a study that looked at how adaptation influenced the level of immersion in a game, i.e. whether PX is affected by players' perception of challenge. It seems that adaptation can indeed lead to increased immersion in the game.

ADAPTIVE GAMES
Despite the obvious benefits of dynamic difficulty adjustment, digital games using algorithms in order to adapt to each player's individual behaviour are not so common. Traditional approaches, such as collecting requirements before and during game development process, seem to be more trusted by game developers. Alpha and beta testing of the game by its potential players, adding appropriate patching, and publishing software development kits (SDKs) for players to modify the game after its release are the most common player-centred approaches currently used by the industry [6].

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However, designing a game based on the requirements of a limited group of potential players can lead to the lack of accessibility of the end product to a wider market. A less risky solution to the problem involves a dynamic modification of a video game to individual players by using player modelling techniques [12] and adaptive game technologies [5]. By reducing the dependency on collecting data about player requirements and the player demographics, digital game companies could instead focus on variations in learning and playing styles, correlate these with personality profiles to avoid problems created by stereotyping players on the basis of age and gender [16].

The hope is that adaptive game technology can be used to moderate the challenge levels for each person, help players avoid getting stuck, adapt gameplay more to one's preferences, or even detect players abusing the game design to their advantage [6]. In multiplayer games, where the difference in skill and experience between players can be large, adaptive algorithms are used more frequently than they appear in single player games, where the main challenge is to beat the game AI. Difficulty adjustment [13], matchmaking, asymmetric roles, and skill and aim assistance [27] are amongst most common techniques, which are believed to improve PX. When a player feels that the game is responsive to them as an individual, they may feel more immersed in the game world, and they experience a heightened sense of enjoyment when the game matches their abilities [22].

One of the goals of adaptive AI design is to find a balance between the player's skill and the level of challenge of the game – to keep the player in the state of flow [19]. Feeling increasingly focused and cut off from the world around is thought to be an important aspect of a positive PX – players enter this state of flow when they find the balance between the difficulty of game play and their own skills while trying to achieve a goal. However, many gaming experiences fall short of the all or nothing experience of flow [3]. For this reason we focus on the commonly experienced but more prosaic outcome of immersion in the game [2]. Immersion is one of the most widely used terms used to describe a feeling of being highly involved in a digital game. Jennett et al. [14] developed a questionnaire to measure this experience, which can also be analysed into five components of cognitive and emotional involvement, real world dissociation, and perceived control and challenge. The questionnaire was statistically validated using a large scale survey and an experiment, and extensively validated in many consecutive studies [4, 8, 10].

The goal then is to see the effect of dynamic difficulty adaptation on the immersive experience of single-player game play. Of course, if players become aware of the adaptation, this could work against the goals of the experiment either through players resenting the adaptation and so experiencing reduced immersion, or through confirmation bias [20] and so reporting (but not experiencing) increased immersion. To avoid this, we have focused on adapting an aspect of games that research consistently demonstrates that players struggle to perceive, namely the passage of time. Nordin [21], throughout his doctoral work, demonstrated that across a range of situations and with a range of psychological measures, players were very poor at tracking the passage of time and were not susceptible to any in-game or contextual manipulation. We therefore used time adaptation as a way of adjusting the challenge of a game so that players would not have any awareness of the manipulation.

STUDY DESIGN

The aim of the designed experiment was to explore the experience of playing a game, in which the challenge is altered to match to player's skills. However, unlike the traditional methods, which modify the challenge by adapting the behaviour of non-player characters, we modified the timer in order to increase or decrease the difficulty based on players' performance and improve the experience of playing the same game for players with different levels of gaming experience. The general idea was to encourage less experienced players by subtly increasing the length of their session in order to allow for the completion of the same goal as other players, whilst providing more challenge for the people with more gaming experience by making the time 'fly by.' The hypothesis was that the people playing the game with altered time would feel more immersed in the game and generally perform consistently better than players with a standard timer.

The experiment to test this hypothesis was a between-subject design with experimental manipulation being the change in time, based on player's performance in the game. The dependent variables were players' immersion, measured using the immersive experience questionnaire (IEQ) [14], where the total immersion was the summary of the Likert-scale points [15], and players' in-game scores used as a measurement of their performance.

Overall, 42 participants (14 women and 28 men) with various backgrounds and varied levels of gaming experience took part in the study. The age range of the players was between 19 and 33 years, with a mean age of 24.05 (sd = 4.19).

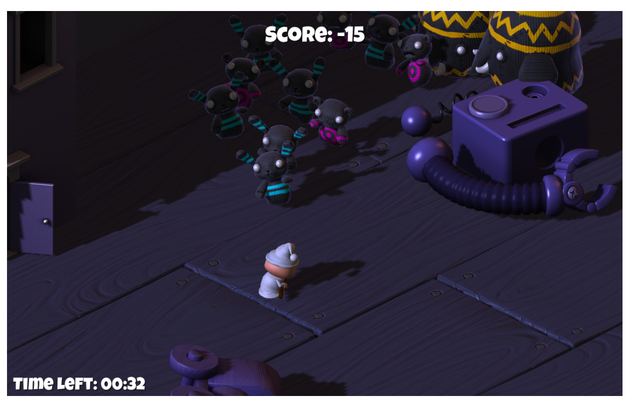

Figure 1. Nightmares: a shooting game.

The game

In order to be able to manipulate the time based on the scores from players, a shooting game was adapted from the tutorial on Unity 4.6 [25], which was then modified based for the purpose of the experiment. The game 'Nightmares' is an isometric view shooting game, in which the player controls a little cartoon-style boy, who is dreaming of his toys turning into zombies and attacking him (Figure 1). The general idea is that every time the character gets attacked by one of the toys, the player loses a certain number of points depending on the toy, or gains points if the player manages to kill it.

The goal set for all players was to score 300 points or more within 90 seconds time limit. This number was estimated from a pilot study as a suitable score, which can be realistically obtained in 1.5 minutes. However, players were encouraged to aim for the highest score they could get. The timer and the score were displayed on the screen at all times.

Two versions of the game were developed: one had a timer with each unit of time being equal to one second, and the other game had the time unit changing based on the scores participants got throughout the game. If participants were doing better than an average player, the timer would speed up by a factor of 1.4, and when the player was doing poorly at a certain period of time in the game, the timer would slow down by the same factor. This time alteration was done four times in the game, at each point checking whether the player's performance was below or above certain requirements.

In order to estimate the potential average scores at various points in the game, 10 participants with varied levels of gaming experience were recruited for the pilot study. Their scores were recorded at five different points in the game and used together with the maximum possible scores in order to estimate the scores required to achieve a realistic number of points (in this case 300) at the end of the game.

Procedure

Before playing the game with the goal in mind each player was allowed to try out the game in a trial session in order to familiarise themselves with the controls. There were no restrictions in time and the score was not recorded, and the players were allowed to stop whenever they thought they were ready for the proper gaming session.

Participants were split into two groups: 20 players in the control group and 22 people playing in the experimental condition. Depending on the condition assigned to the group, participants either played the game for 1.5 minutes or for what appeared to be 1.5 minutes. During the experiment participants' scores were compared to the recorded scores from the pilot, at four points in the game – every 20 seconds. If the player was performing better than the pilot players throughout the whole game, the time would be eventually reduced from 90 seconds up to 72 seconds. Alternatively, for those players, whose scores were below recorded values, the time would be extended up to 108 seconds. However, if the player was performing similarly to the average requirement to reach the goal, the timer stayed unchanged. After that, they filled in the IEQ questionnaire, then the demographics questionnaire, and after that each participant was fully debriefed.

RESULTS

We hypothesised that the variation in players' scores would be more tightly positioned around the goal of 300 points when playing with adaptive timer, and that these players would feel more immersed in the game in this condition. Both statements were supported by the results. The participants who played the game without any modifications to the timer were significantly less immersed, than those participants whose timer was changing based on their performance (Table 1), as determined by one-way ANOVA ($F(1, 40) = 7.41, p = 0.010$), with a medium effect size ($\eta^2_{\text{partial}} = 0.156$). SD is within the acceptable range for assuming homogenous variance [1].

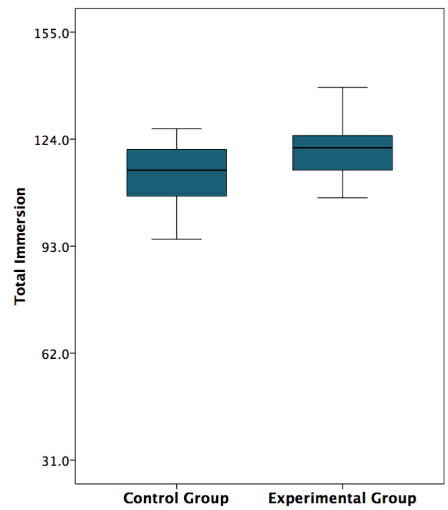

Figure 2. Total immersion with and without adaptive timer.

In terms of immersion components, the analysis is summarised in Table 1. Significant differences were seen in the cognitive involvement and control aspects of immersion with differences in emotional involvement approaching significance. There was no significant difference in the real world dissociation and challenge components, the difference in conditions showing very small effects in both components.

Out of the 22 participants in the experimental group, 9 people had a shorter gaming session and 10 participants played for longer than 90 seconds. However, due to the time manipulation, there were 3 more players, who played for exactly 90 seconds because their time was varying in both directions equally at certain points in the game.

There was no significant difference between the immersion scores obtained from participants playing shorter sessions and players with extended time: $F(1, 18) = 0.08, p = 0.781$. Moreover, there was no correlation observed between the immersion scores and the length of the session (Pearson's $r(21) = -0.09, p = 0.583$).

Total Scores

The scores in the control group had much bigger variation than the scores obtained by players in the experimental condition, as expected. The average score in the control group was 341.9 ($sd = 144.34$), and ranged from -106 to 474, while the experimental group obtained scores on average higher that the required 300 points – 391.5 ($sd = 50.30$), and ranged between 258 and 494. However, there was no

Components	Adaptable Timer		Standard Timer		$F(1,38)$	p	η^2_{partial}
	Mean	Std.Dev.	Mean	Std.Dev.			
Total Immersion	121.05	8.11	113.50	9.83	7.41	0.010	0.156
Cognitive Involvement	39.64	3.02	37.45	3.35	4.96	0.032	0.110
Emotional Involvement	21.55	3.74	19.60	3.17	3.28	0.078	0.076
Real World Dissociation	25.09	3.60	24.05	4.22	0.74	0.394	0.018
Challenge	14.18	1.65	13.50	1.93	1.52	0.225	0.037
Control	20.59	2.56	18.90	2.45	4.77	0.035	0.107

Table 1. Average levels of immersion and its components in control and experimental groups.

significant difference between the scores of the two groups: $F(1,40) = 2.30, p = 0.138$.

The scores obtained in the experimental group also differed between those participants who played for longer than 90 seconds and participants, whose gaming time was reduced. The average scores in the group with extra time was 357.6 (sd =43.59), while participants scored more when being under pressure – the group with reduced time managed to get 419.9 on average ($sd = 37.71$). The difference in the scores was significant: $F(1,18) = 10.97, p = 0.004$ ($\eta^2_{\text{partial}} = 0.392$) (Figure 3).

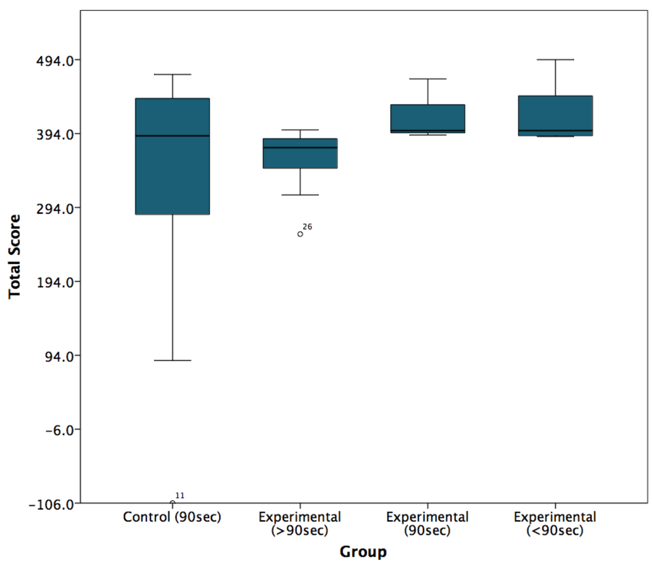

Figure 3. Total scores obtained by each group with regards to the time in relation to 90 seconds threshold.

Players' immersion was positively correlating with their performance in the game (Pearson's $r(21) = 0.34, p = 0.029$).

DISCUSSION AND CONCLUSIONS

The results of the study demonstrated that even simple adaptation of a timer, based on player's performance, can affect their gaming experience. Although this manipulation was not as elaborate as some adaptive game, it still was able to affect PX by matching the goal to the player's performance. Players felt more immersed in the game when the timer was changing according to their performance in the game. This may be why those in the experimental group experienced a greater sense of control, as measured in the IEQ, the game was more appropriate for their ability to assume control in the game. Further, as there was no correlation between level of immersion and time that they played, the difference in immersion could not simply be because some players got to play for longer than others.

No participants reported noticing the change in the speed of the timer, nor did the participants in the two conditions differ in their level of perceived challenge. This suggests that their experience was purely based on their playing experience without being aware of the underlying causes of the experience. Regardless of how much time players spent in the game, they were convinced they achieved their results within the required amount of time. For those who had reduced time, they were performing well, but consequently had more pressure to continue to do so. For those with increased time, they were not performing so well, but therefore got more time that allowed them to achieve the target goal. This may suggest that different mechanisms are influencing the experience when games are adapting to players, particularly when there is a pre-specified goal against which players can monitor their progress.

Interestingly, players under time pressure and with shorter sessions achieved higher scores on average than some players in the control group, which is attributed to the fact that their performance was consistently good throughout the whole session. More skilled players were motivated to achieve the highest possible score, while players with less skill seem to have felt that reaching 300 in the game was challenging enough. As might be expected, players in the control group showed larger spread in scores, particularly below the target 300, but the overall difference in scores was not significant.

Overall then, the general expectation that dynamic difficulty adaptation leads to better PX is supported by this study. Of course, this study represents only a particular type of game over a single instance of play. Different games may produce different results, and it is also not clear how knowledge of the adaptation may influence experience. It may be that over repeated play, players become aware of adaptation and therefore feel 'short changed' by the game or that it is in some way unfair. The perception of fairness is a well-known issue with adaptable technologies in multiplayer games [11], while little is known about how adaptations are perceived in single-player games. Moreover, longer or multiple gaming sessions could have influenced immersion over time. All of these considerations lead to promising avenues of research before we can fully accept that adaptive AI is indeed effective in improving player experiences.

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