The Use of Eyetracking for Measuring Immersion

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Abstract

Games arguably have the most impressive success of any computer-based application and it would be useful to be able to extract some of the successful features of games for use in different application areas. Whilst games are clearly a multi-faceted phenomenon, when talking about games, gamers and reviewers often refer to the immersive experience of the game as being of particular importance. Moreover, the term immersion can be applied across many different genres of games from first person shooters, to strategy games and simulations. However, whilst many people use the term immersion, it is not clear exactly what this term means or whether the experience of immersion is the same across different games. Earlier qualitative studies (Brown & Cairns, 2004) showed that immersion can be better understood as a scale of experience with lower levels of immersion leading to higher levels. The purpose of our current work is to consider if it is possible to quantify the experience of immersion through more objective measures of the cognition of an immersed person such as eye-movements.

Introduction

Brown and Cairns (2004) reported that "total immersion" is a stage in which the gamer feels like they are cut off from reality, the computer game being all that mattered. Furthermore, Cairns, Cox, Dhoparee, Jennett and Hong (under review) found that people reported feeling immersed when reading books and watching films, as well as playing computer games. However, despite the word's common usage, it is still not clear how to measure immersion. So far there have been various attempts to measure immersion using questionnaires. For example, Cairns, Cox, Dhoparee, Jennett and Hong (under review) found that the personality trait of absorption is positively correlated with immersion in both reading books and watching films. They also found that rather than giving participants a lengthy immersion questionnaire, the simple question of asking participants to rate their degree of immersion on a ten-point scale can also be a reasonable indicator of immersion.

In a prior study, we used task completion times to measure immersion. Participants were asked to solve a tangram task before and after playing an immersive computer game (i.e. the opening sequence of the first-person shooter HALF_LIFE™) or "playing" a non-immersive control task (i.e. clicking random buttons as they appeared in random sequences on the screen). The results revealed that participants in the experimental condition did not improve their task completion times as much as control participants, suggesting that the immersion task was interfering with the participant's learning or their ability to switch out of the game to the real world task.

However, even though task completion times are a more objective way to measure immersion, like questionnaires they too are susceptible to many confounds. Therefore, it is evident that researchers are still yet to find a more reliable way to measure immersion. In this study we propose that analysing changes in explicit and online behaviours during gaming, such as eye movements, might be the answer.

Eye-tracking has become an increasingly popular methodology for measuring attention, and with recent developments in technology it is becoming increasingly reliable too. In the past, eye-tracking has been used to analyse how people read, perceive scenery, artwork, and films (Duchowski, 2003). Recently, eye-tracking has also been used to investigate interactive search on web-like menus (Cox & Silva, 2006) and attentional paradigms such as inattentional blindness (Koivisto, Hyona & Revonsuo, 2004; Memmert, 2006; Pappas, Fishel, Moss, Hicks & Leech, 2005; and change blindness (Hollingworth, Williams & Henderson, 2001; Triesch, Ballard, Hayhoe & Sullivan, 2003). However, when it comes to how people perceive computer games, very little is known.

In Brown & Cairns (2004)'s qualitative study involving gamers, one gamer commented that in total immersion "you feel like you're there." Similarly, another gamer made the comment that total immersion is "when you stop thinking about the fact that you're playing a computer game and you're just in a computer." These are experiences that we can all probably relate to. For example, in a shooting game a gamer might feel scared when a character suddenly pops up unexpectedly and starts shooting at them. In an adventure game, a person might feel excited as they figure out how to open a locked door to enter a new room.

As a result of such experiences, one can suggest that gamers actually feel as if they are viewing a real scene when they are immersed. In a review of eye-tracking studies investigating scene perception, Rayner (1998) reports that the gist of a static scene is extracted from the first few fixations, and then the remainder of the fixations are more focused on particular objects, to fill in the details. Similarly, in the attention literature Styles (1997) reviews a number of studies that suggest that visual attention can be compared to a zoom lens: initially attention is widely distributed over all elements of the display, but then attention is narrowed down and becomes more focused.

However, whereas the scenes talked about in this past literature are static, in a computer game the scene is always changing. Therefore, rather than eye movements becoming focused on fewer objects, as time progresses one might predict that as a gamer becomes more immersed in the game and attempts to take in the whole scene while meeting the demands of the task the number of saccades will increase. In contrast, for a non-immersive game one might predict that the number of saccades will decrease over time; not necessarily because the person is focusing in on the task but because they are more likely to "drift off" as they become bored.

The proposed experiment aims to test these ideas by analysing the changes in participants' eye movements while they engage in either an immersive or non-immersive task. After ten minutes, an immersion questionnaire will be administered to measure the level of immersion reported by participants. For example, one might predict that participants who exhibit changes in eye movements associated with immersion should have higher self-reported ratings of immersion than participants that did not exhibit such changes in eye movements.

In an another attempt to test whether the behavioural measures relate to immersion, ratings of absorption or openness to experience (two personality traits closely related to immersion) will be correlated with the eye movement data. Also, in replication of Cairns, Cox, Dhoparee, Jennett and Hong (under review), it is predicted that participants who score high on absorption will have significantly higher immersion scores than participants who score low on absorption.

Overall, the proposed study has three main hypotheses:

(1) Participants in an immersive condition will show a different pattern of eye-movements over the duration of the task, than participants in a non-immersive condition.

(2) Subjective self-reported immersion ratings will correlate with these objective behavioural measures of immersion.

(3) Personality ratings will also correspond with these behavioural measures, participants who score high for traits associated with immersion (i.e. absorption and openness to experience) exhibiting immersive behaviours sooner and for longer periods than participants who score low for these traits.

Experiment

Method

Design. The proposed experiment is an independent measures design. Participants will be assessed for two personality traits linked to immersion: absorption (high absorption / low absorption) and openness to experience (high openness / low openness). They will then complete one of two tasks: a non-immersive task or an immersive task (the computer game HALF_LIFE^{TM}). In both tasks eye tracking will be used to explore how the participants' eye movements change during the task (i.e. the number of fixations, fixation duration, and saccade length).

Participants. 40 participants will take part in this study, 20 in each task condition.

Materials and Apparatus. Three questionnaires in paper format will be used: the Multi-dimensional Personality Questionnaire, to measure absorption (Tellegen, 1982); the NEO Five-Factor Inventory (Costa, & McCrae, 1992), to measure openness to experience; and the Immersion Questionnaire (Cairns, Cox, Dhoparee, Jennett & Hong, under review), to measure self-reported levels of immersion.

The non-immersive task will be programmed using Visual Basic 6.0 and designed to be as minimally engaging as possible. (This will be a replication of the non-immersive task reported in Cairns, Cox, Dhoparee, Jennett & Hong, (under review).) Participants will be presented with a small square on the screen which they will have to click with the mouse as quickly and accurately as possible. Clicking the square will cause it to disappear and reappear somewhere else on the screen (in another location at any point on an invisible 9 by 9 grid, for which the coordinates are generated randomly) to create a pattern that the participant must follow.

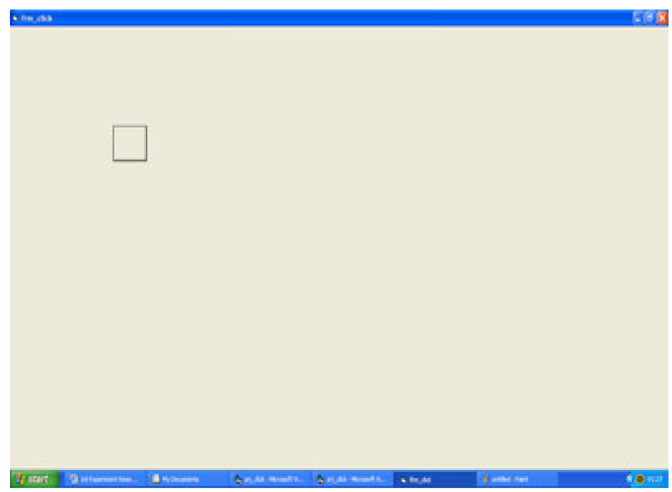

FIGURE 1. *Sample of the experiment interface in the non-immersive condition. It is the participant's task to simply click the square when it appears on the screen.*

The first immersive task will be the first-person shooter game HALF_LIFE^{TM}. The game configurations will be displayed on a paper placed in front of participants in order to cause minimum disruption while playing (controls being instantly accessible). All three tasks will be run on a PC for a duration of 10 minutes each.

A Tobii 1750 eye tracker will be used to collect the data. Participants will sit approximately 60 cm away from the stimulus, which is the optimum distance to collect good eye movement data.

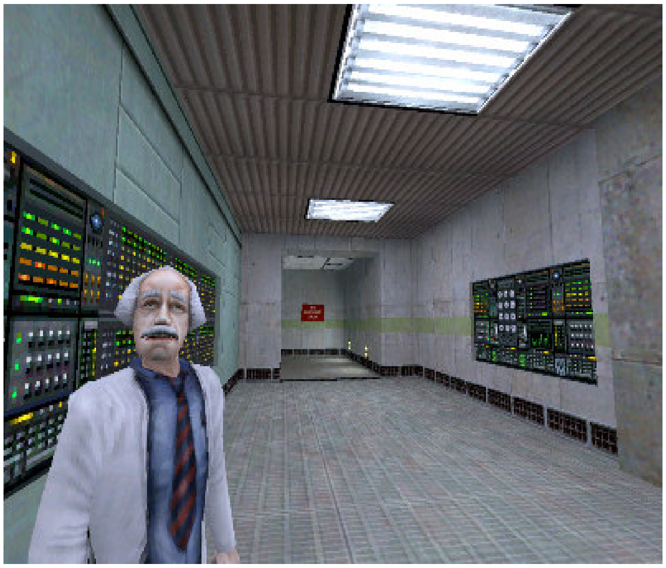

FIGURE 2. *Sample of the computer interface in the first immersive task, HALF_LIFE™. In this opening sequence, it is the participant's task to make their way around a research building to find their hazard suit.*

Procedure. Each participant will complete two pen-and-paper questionnaires: the Multi-dimensional Personality Questionnaire (indicating whether they have high / low absorption) and the the NEO Five-Factor Inventory (indicating whether they have high / low openness to experience).

Upon completion of calibration on the eye tracker, participants will be presented with one of the tasks: the non-immersive task (clicking squares) or the immersive task (playing the first- person shooter HALF_LIFE™). Allocation to each condition will be random for all participants.

In both conditions participants will be told beforehand that they will have ten minutes to perform the task, after which time they will be interrupted (the warning avoiding startling participants). Participants will then be asked to fill out an immersion questionnaire, rating their experiences in the task (again pen-and-paper). After completing the questionnaire, all participants will be fully debriefed and receive payment.

Proposed Analysis of Results and Implications

Eye movements. Eye movement data (i.e. the number of fixations, fixation duration, and saccade length) will be recorded at ten second intervals. A regression analysis will be carried out to determine whether there is a significant change in eye movements as the participants engage in the task. It is predicted that during the immersive tasks, participants will show a greater number of short fixations over time as they become more immersed in the game, taking in the whole virtual environment. In contrast, it is expected that in the non-immersive task participants will show fewer fixations with longer durations over time, as they lose motivation and begin to "drift off".

Immersion Ratings and Personality Ratings. Immersion scores will be calculated for each participant and using a t-test, it is expected that the mean immersion score for participants in either of the immersive conditions will be higher than the mean immersion score for participants in the non-immersive condition.

Participants' personality ratings in relation to their immersion ratings will also be analysed, using correlations. In replication of Cairns, Cox, Dhoparee, Jennett and Hong (under review), it is predicted that participants who score high on absorption will have significantly higher immersion scores than participants who score low on absorption. It is predicted that participants who score high on openness to experience will also have significantly higher immersion scores than participants who score low on openness.

In terms of personality and eye movements it is also predicted that participants who score high on absorption and openness will show behavioural changes related to immersion sooner than participants who score low on these personality measures.

Implications. If eye movements are found to change during an immersive task, such results could be useful in establishing an objective way of measuring immersion. This would have practical applications for computer software designers and HCI researchers alike.

We hope to be able to report initial results at the workshop.

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