Effects of Sensory Immersion on Behavioural Indicators of Player Experience: Movement Synchrony and Controller Pressure

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ABSTRACT

In this paper we investigate the relation between immersion in a game and the player's intensity of physical behaviours, in order to explore whether these behaviours can be reliably used as indicators of player experience. Immersion in the game was manipulated by means of screen size (20" vs 42" screen), and sound pressure level (60dBA vs 80 dBA), according to a 2 x 2 design. The effects of these manipulations on self-reported experience (including arousal and presence) and behavioural intensity (controller tilt and button pressure) were measured. Results showed that sound pressure level in particular strongly influenced both the self-reported measures of people's affective reactions and feelings of presence and the force people applied to the interface device. Results from controller tilt demonstrated that participants did move along with the dynamics of the game. The measure was, however not sensitive to either of the two manipulations of sensory immersion. In the paper the implications for the use of behavioural indicators of player experience in general and the feeling of presence are discussed.

Author Keywords

player experience, movement synchrony, interface pressure, behavioural tracking, presence

INTRODUCTION

Much understanding of player experience is founded in players' verbal accounts. These can be recorded either during (e.g. using think aloud protocols) or after a game session has been completed, and qualitatively (e.g. depth interviews, focus groups) or qualitatively (e.g., standardised questionnaires). In addition to these self-report measures recent research has focused on the inclusion of behaviour-based measures in the measurement repertoire [e.g., 4]. In this line of research behavioural responses are referred to as naturally occurring physical and social behaviours, exhibited during an episode of game-play, as a direct response to unfolding game events and/or social interactions. Once validated, the advantages of such measures are that they are continuous and real-time, without disrupting the experience under scrutiny. For this reason, the use of real-time continuous behavioural measures (e.g., movement synchrony or pressure exerted on a gamepad) and psychophysiology as indicators of player experience have recently received more attention. Eventually, the output of continuous measures of player experiences may even become real-time input to the game engine, allowing the game's AI to adjust to the player's affective or cognitive state at any point during gameplay. However, such uses critically depend on a thorough understanding of the relation between player behaviour and player experience

Behaviour as indicator of player experience

Before behavioural measures can be incorporated into the feedback loop between user and the device being used, the link between behavioural characteristics and players' experiences will have to be clarified, and specified to an extent that a computer can use them. Recent research has made several steps towards this understanding and qualification of behavioural characteristics.

Behaviour displayed during game play has been demonstrated indicative of internal affective states. For instance, postural patterns have been found to be indicative of learner interest [16], synchronous movement with visual stimuli has been related to feelings of immersion and presence [1; 7], and level of difficulty of the game has been related to the pressure people exert on an interface device

Breaking New Ground: Innovation in Games, Play, Practice and Theory. Proceedings of DiGRA 2009

[22]. Particularly the latter finding has been debated as some research seems to suggest that the force people apply to interface devices can be interpreted as an indicator of negative arousal [15; 17], while from other research it can be concluded that it need not be related to negative arousal alone, but can be related to arousal in a more general way [e.g., 5; 24]. Interestingly, the research by van den Hoogen et al. [5] may even be taken to suggest that multiple behaviours may be indicative of the same emotional experience. That is, in addition to replicating the findings of Sykes and Brown [23] that people apply more force on the interface device as difficulty is increased, van den Hoogen and colleagues found that people moved more intensely in their seats during game-play as the level of difficulty increased. Correlational analyses with self-reported measures of the player experience indicated that behavioural intensity was related to people's level of arousal [5].

The precise interpretation of behavioural indicators (e.g., what specific emotion does interface pressure signal?) is currently debated. What is clear, however, is that behaviour spontaneously occurring during game-play can be indicative of people's emotional experience. In fact, behavioural measures have already been found useful in creating emotionally adaptive games [3; 24]. Notably, Tijs et al. [24] demonstrated keyboard pressure to be a reliable indicator of player experience, and useful for the adaptation of the game speed. Outside the scope of digital games, [9] have shown that data from multiple modalities (e.g., facial expressions, posture, and pressure mouse) may also be used together in the automatic prediction of whether someone is about to click an 'I am frustrated' button. It seems fair to say that behavioural measures are already being used, and it is showing promising results for future use. What needs to be done is facilitate this use by mapping people's behaviour to specific and more diverse affective states, and providing a more thorough understanding of the (probably complex) relation between behaviour and people's internal affective states.

Immersion, presence and player experience

Although the results mentioned above are encouraging for the utility of behavioural indicators of player experience, the focus of much research has been on the balance between challenge of a game and the skills of the player. Challenge however, is but one aspect of a player's experience of digital games. Another important and often referred to aspect is immersion [e.g. 2; 22; 10; 18]. When a game is truly immersive it is said that people are drawn into the game and its story, or are engulfed in its sensory output. This psychological experience strongly relates to the concept of 'presence' used in virtual reality research to describe people's 'feeling of being there' in the simulated or mediated environment. To prevent any confusion resulting from the different uses of jargon in different research domains, *both* the term 'presence' and 'immersion' are used in the literature on virtual environments. There the convention is that 'immersion' denotes the objective degree to which technical characteristics of a system insulate persons from their 'real' physical surroundings, and engulf them in a wealth of mediated sensory information. 'Presence' on the other hand, is conceptualized as the experiential counterpart of immersion [6]. To put it shortly, in virtual environments literature technology may be immersive, but whether a person does or does not experience 'presence' is subjective.

In spite of the fact that 'presence' is subjective, research has indicated that several objective immersive characteristics consistently show a positive effect on this experience. Two characteristics which also fit well with digital games are screen size and audio characteristics like the volume level. The first, screen size - or more to the point Field of View (FOV) - has repeatedly been found to be an effective way of manipulating self-reported measures of presence [e.g. 13; 19; 7]. A second, less used, way of influencing the level of immersion of a mediated experience is by changing characteristics in the auditory information. Just as a large screen can be considered more immersive than a small screen, so can high quality sound create a stronger, more immersive experience than the use of low quality sound In fact, research by Wood, Griffiths, Chappell, and Davies [25] indicates the realism and quality of both sound and graphics to be important characteristics for the enjoyment of a game. Further, from a gamers' point of view, audio has been suggested to be an important factor for keeping players immersed in the game [21].

As can be concluded from the literature mentioned above, much research indicates that as a mediated experience becomes more immersive and perceptually realistic, people tend to feel more present – i.e. more immersed, more engaged - in the mediated environment. It is our expectation that, as people experience a stronger feeling of presence it is likely that people will also react more strongly as if they are really there, i.e., assuming more 'behavioural isomorphism' with more 'experiential isomorphism' for mediated and unmediated stimuli [6]. Consequently, as people feel more engulfed by the game, it could be argued that people's level of arousal will increase and, consequently, their behaviour will become more intense. Using a race game, for instance, it seems more likely that when people are more immersed in the game and feel more present in their virtual race car, they will also use the controller with more vigour and will move the controller more in synchrony with the turns in the track.

In the current study we aim to clarify the relation between immersion, player experience, and behavioural intensity. By that, we also aim to provide more insight into the general applicability of behaviour-based measurements of player experience.

METHOD AND PROCEDURE

Participants

Participants were mostly university students with the exception of 1 high school student and 1 working participant. In total 24 persons participated in the study, ages ranging between 18 and 26 (M=22).

Design and procedure

The study was conducted as a 2 (screen size: small 20" vs. large 42") by 2 (sound pressure level: low, 60dB vs. high, 80dB) within subjects design. The four experimental conditions were fully counterbalanced.

Participants played four tracks in the race game 'Need For Speed: ProStreet' (one track in each experimental condition), each of which would last between 5 to 10 minutes depending on their skills. During game-play participants were video-taped. Participants were told that the aim of the study was to measure their gaming performance under different auditory and visual conditions. To motivate participants to really play as well as they could, they were told that their scores would appear on a high score board, placed prominently in the entrance hall.

The game was played on a PC with the PS2 controller connected to it. The PC allowed us to completely control the visual output resolution. After each race participants filled in a questionnaire and were asked to momentarily leave the room. The experimenters would then change the volume level and screen size according to the specified condition. Participants re-entered the room, and played the next condition. This procedure was repeated until they had played all four conditions. After the last condition, participants were thanked, paid and debriefed.

Manipulations

screen size

The first manipulation of sensory immersion employed was that of the screen size. Two screens were used, a small and a large one. The small screen was a 20" TFT monitor (width 43.5 and height 27 cm) with a viewing distance to screen of 1.75m resulting in a FOV of 14.2º.

The large screen was a 42" TFT TV (width 93, height 52 cm). The viewing distance to the screen was 1.90m resulting in a field of view (FOV) of 27.5º.

For both screens the resolution was set to 1680 x 1050 pixels in order to keep the information on the screen identical, and only change the apparent screen size.

sound pressure level

As a manipulation for the sound component of sensory immersion the sound pressure level (SPL) was chosen. Although this characteristic of sound has, to our knowledge, not been used before, like the manipulation of screen size it amplifies the signal without changing the content, which the use of mono vs. stereo sound would have done.

The sound was generated by the game engine as a Dolby 7.1 signal, which was transferred to a high quality amplifier. Background music was eliminated from the game as to make sure only game related sounds would be part of the sensory immersion. This was done as it has been found that the addition of music in a game can substantially influence people's experience [12]. In the low SPL condition the volume was set to an output of 60dBA at the position of the participant, while in the high SPL the output was set to 80dBA.

measurement instruments

self report measurements

As a measure for the subjective player experience the self assessment manikin (SAM) scale was used. The SAM scale is a visual self report scale developed by [11] and based on [14] Pleasure-Arousal-Dominance (PAD) theory. The SAM-scale visualizes the three PAD-dimensions. Each dimension is depicted through a set of five graphic figures (manikins) and for every dimension respondents have to indicate which figure corresponds best with their feelings on a nine-point scale. The first dimension P (displeasure/pleasure) ranges from extreme sadness to extreme happiness. The second dimension A (non-arousal/arousal) ranges from very calm or bored to extremely stimulated. The third dimension D (submissiveness/dominance) ranges from a feeling of being controlled or dominated to a feeling of total control.

Presence was also measured using a SAM-based measure developed by [20]. This dimension ranges from a feeling of total absence of presence to a feeling of total presence For each SAM dimension we asked participants to indicate, on a 9-point scale listed below the graphical presentation, which manikin corresponded with their experiences during game-play. Scale values ranged from 1 to 9, with ascending scores corresponding to higher pleasure, arousal, dominance and presence ratings.

behavioural measures

The characteristic of behaviour that was of particular interest was its intensity. In the current paper this was operationalized using two behavioural indicators: movement synchrony with in-game events and force exerted on the controller button. A Sony Playstation Dual-Shock 2 controller was modified to measure pressure exerted on selected buttons and to measure acceleration from which we derived its tilt.

Movement Synchrony was calculated using observational coding of left turns, right turns, and straight part in the game, and calculating mean controller tilt over these game sections. Controller tilt was measured using a Phidgets 3 axis accelerometer mounted on the bottom of the game controller. The data from the axis running from left to right over the controller was smoothened providing a measure of controller tilt. For each condition this resulted in a measure of average tilt during right turns, left turns, and straight sections of the game separately, indicating lateral sway movement synchrony of the gamer. Positive values indicate left controller tilt and negative values indicate right controller tilt.

Force applied to the input device was measured using flexiforce pressure sensitive strips (build by TekScan). Pressure sensitive strips were built below several buttons of the game-pad, including the throttle-button of the game controller (the X). A range correction was applied to the pressure data, restricting the maximum value per person to one. This was done in order to cope with individual differences in pressure exerted (e.g., as a result of muscle strength) and potential differences in sensitivity of the pressure sensors.

RESULTS

self-report measures

To analyze the self-report measures 4 separate repeated measures ANOVA's (REMANOVA) were conducted. These showed a main effect of Screen Size for presence only ($F(1,23)=6.11$, $p=.02$), with presence rated higher with the large screen as compared to the small screen. This effect is consistent with findings from previous research and signals that the screen size manipulation successfully influenced people's experience of presence. Further, a main effect of Sound Level was found for arousal ($F(1,23)=15.57$, $p=.001$), presence ($F(1,23)=5.30$, $p=.03$), and dominance ($F(1,23)=4.83$, $p=.04$). All main effects were such that scores for the measures (arousal, presence and dominance) were highest when the Sound Level was highest. Similar to the screen size manipulation, an increase in sound pressure level thus induced a positive effect on people's feelings of presence. Additionally, this manipulation influenced people's feelings of dominance and arousal, indicating that the increase in sound pressure did influence people's emotional states in a more diverse way than did the manipulation of screen size. In short the results indicate people to have been more juiced up by the sound pressure level manipulation. Consequently, it seems more likely that the behaviour will also be more strongly influenced by the sound pressure level manipulation than the screen size manipulation.

behavioural measures

Two behavioural measures were used: movement synchrony and interface pressure. To analyze movement synchrony a difference score between mean controller tilt for the right and left corners in the track was used. The more participants moved in sync with the turns in the track, the higher was the resulting difference score. A REMANOVA showed no effect of Screen Size or Sound Level on this difference score. Thus, synchrony of movement was not influenced by the manipulations. An additional analysis was conducted to test whether there was any movement synchrony at all. For this, the dataset was restructured creating a variable for left turn, right turn, and straight controller tilt separately. Using a REMANOVA it was found that the direction of the turn did result in significant differences in the controller tilt ($F(2,94)=4.56$, $p=.013$) with left turns having more positive values (indicating more left controller tilt) than right turns ($M_{left}=0.06$, SD=0.12; $M_{right}=.009$, SD=0.17). Values for straights were in between that of the left and right turns in the track ($M_{straight}=0.036$, SD=0.11). The results show that, using the controller-tilt measure, there was synchrony of movement. It was, however, unaffected by the manipulation of both screen size and sound pressure level.

The second measure used in the study was interface pressure. Using a REMANOVA a main effect of Sound Level was found on interface pressure ($F(1,23)=6.36$, $p=.019$) with more force being applied to the controller buttons when Sound Level was high (M=0.65, SE=0.04), as compared to the low Sound Level conditions (M=0.47, SE=0.05). This result shows that as a result of an increased sound pressure level people did press harder on the controller button.

DISCUSSION

In this study we tested the utility of behavioural indicators – pressure exerted on gamepad buttons and movement of the controller in sync with in-game events – as indicators of player experience in a race game. To do so, screen size and sound pressure level were manipulated to impact player experience. Scores and effects on the behavioural indicators were then compared with effects on self-reported experience of presence, arousal, dominance and pleasure.

Effects on self-report measures of game experience were clear. Firstly, previous findings indicating that an increase in FOV results in higher ratings of presence were replicated. With a larger FOV players felt more present in the game episode.

Similar to the findings for screen size, the sound pressure manipulation also turned out significant. As the sound pressure level increased, so did the ratings of presence. Additionally, participants reported to have experienced higher levels of arousal and dominance as a result of the sound pressure manipulation. In combination, these results reflect that as a result of an increase in strength of the auditory information, people had a more intense playing experience, felt greater presence and felt more in control.

In the introduction we specified that we expected that in such conditions the intensity of players' behaviour would also increase. The results partly support these expectations. The results from the controller tilt were least strongly related to the manipulation of sensory immersion. Neither of the manipulations influenced the synchrony of movement with in-game events – i.e. left and right turns in the track. Whether the screen size or sound pressure level were high or low, no differences in synchronous controller tilt – indicating that the players did not rotate the controller more to the left or right in sync with the turns of the track - was observed. This could be due either to participants not moving in synchrony with the game (i.e. no relation between the key events and player movement), or, alternatively, no increase of movement synchrony as a result of the manipulations used. The results show the latter explanation to be true, that is, it was found that in right turns on the race track people did tilt the controller more to the right than in left turns. Most notably, on the straight part of the tracks, people held the controller in between the tilt-values for the right and left turns. Clearly this indicates that people *did* move in synchrony with the game events, yet simply did not do so more when the sensory immersion was increased. From a practical point of view, controller tilt is a useful measure for detecting players' synchrony of movement with in-game events.

The results for the second behavioural measure were more straightforward. The findings show that controller pressure was highest in the conditions in which people also reported to be most aroused, felt most present, and felt most dominant during the game. Thus, when self-report measures indicated higher arousal and presence, players pushed the buttons on their gamepad harder. Interestingly, this seems to provide additional support for recent findings [5] that suggest interface pressure to be related to more than 'only' the experience of frustration.

In sum, the study reported in this paper replicates the effect increased FOV has on feelings of presence. Increased sound pressure levels also resulted in an increase in ratings of presence. Moreover, sound level manipulations also influenced players' arousal and feeling of dominance in the game. Notably, the effects are found in the content of digital gaming: an interactive technology that is already designed to grasp people's attention and immerse them as best as they can. It thus shows all the more strongly the relation between the immersiveness of the media technology and the experience of presence, immersion and engagement. As for the relation between sensory immersion and behavioural indicators the results clearly show their worth. While the sensitivity of the controller tilt measure for the manipulations was too low to be picked up in the current study, the direction of the corner was picked up with the tilt measure. More directly related to the manipulation, interface pressure was influenced by the sound pressure manipulation. In all, behavioural measures clearly have potential, although assigning these indicators to specific experiences remains a challenge, and additional studies are needed to optimise the measure's sensitivity to pick up differences in people's experience.

ACKNOWLEDGEMENTS

The authors would like to thank Bo Merkus, Dylan Schouten, Saskia Maan, and Roelof Lochmans, for their help in conducting the experiment reported on in this paper.

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