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More than a feeling: Measurement of sonic user experience and psychophysiology in a first-person shooter game

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ABSTRACT

The combination of psychophysiological and psychometric methods provides reliable measurements of affective user experience (UX). Understanding the nature of affective UX in interactive entertainment, especially with a focus on sonic stimuli, is an ongoing research challenge. In the empirical study reported here, participants played a fast-paced, immersive first-person shooter (FPS) game modification, in which sound (on/off) and music (on/off) were manipulated, while psychophysiological recordings of electrodermal activity (EDA) and facial muscle activity (EMG) were recorded in addition to a Game Experience Questionnaire (GEQ). Results indicate no main or interaction effects of sound or music on EMG and EDA. However, a significant main effect of sound on all GEQ dimensions (immersion, tension, competence, flow, negative affect, positive affect, and challenge) was found. In addition, an interaction effect of sound and music on GEQ dimension tension and flow indicates an important relationship of sound and music for gameplay experience. Additionally, we report the results of a correlation between GEQ dimensions and EMG/EDA activity. We conclude subjective measures could advance our understanding of sonic UX in digital games, while affective tonic (i.e., long-term psychophysiological) measures of sonic UX in digital games did not yield statistically significant results. One approach for future affective psychophysiological measures of sonic UX could be experiments investigating phasic (i.e., event-related) psychophysiological measures of sonic gameplay elements in digital games. This could improve our general understanding of sonic UX beyond affective gaming evaluation.

1. Introduction

Research efforts are beginning to unravel the epistemological, ontological and methodological nature of user experience (UX) to foster a better general understanding and give rise to structural models of this concept (Law et al., 2008). In addition to the structural efforts involved in creating models of UX, discussions of UX measurement techniques and experimental results from UX studies form the basis of our growing understanding of this research field. While digital games have been the focus of some of these efforts (Bernhaupt et al., 2008; Nacke, 2009b), qualitative and quantitative studies of UX in digital games are still few in number, especially where sound is concerned. This is partly because of the shortage of research on what UX measurement techniques can be applied to evaluate the affective experiences of digital gaming and how. Digital games are designed for entertainment; hence, the emotional and affective aspects of UX when interacting with games concern game developers directly. Emotions in digital games act as a motivator for the cognitive decisions players make during gameplay and they drive UX in digital games (Nacke, 2009a; Nacke and Lindley, 2009). In this paper, we outline the motivation and hypotheses for an empirical study investigating effects of sonic UX in digital games. The methodology and results of the empirical study are reported and discussed and, in particular, correlations between subjective experience and physiological data are analyzed. Finally, we conclude on the suitability of psychophysiological measurement for assessing sonic UX in digital games and give an outlook onto our future work in this area. Our long-term motivation in pursuing this experimental line is to investigate a player's experience of sound in digital games to work towards a model of such experience, which should function as a practical guide for game sound design – especially addressing the potential of new technology. Thus, by presenting our measurement methodology and results, we hope to provide a foundation upon which a structural model of sonic UX in digital games can be built in future research.

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1.1. Psychophysiological measurement and the dimensional emotion model

Psychophysiology uses physiological signals, recorded with electrodes on the skin, to obtain information about a user's emotional and mental state. Traditionally, these signals were explored in the areas of neuroscience, medicine or biomedical engineering but they have recently been introduced to human–computer interaction (HCI) research (Fairclough, 2008; Mandryk and Inkpen, 2004). The measurement is not particularly obtrusive and has been used to covertly assess emotional reactions of users engaged with interactive entertainment products such as digital games (Nacke and Lindley, 2008; Ravaja, 2004). Two approaches have emerged in HCI research and are starting to gain popularity because of their relatively easy deployment and analysis. Facial electromyography (EMG) describes the measurement of subtle electrical activation of face muscles and is a good indicator of pleasant or unpleasant emotion (Bradley and Lang, 2007). Electrodermal activity (EDA) is a very common psychophysiological measurement method due to its very easy application (Boucsein, 1992). EDA is regulated by production of sweat in the eccrine sweat glands, where increased sweat gland activity is related to electrical skin conductance level (SCL), and is associated with physical arousal (Lykken and Venables, 1971).

To evaluate EDA and EMG measurements, dimensional theories are *de facto* standards used in psychophysiological research. One of the most influential dimensional models in emotion assessment, the circumplex emotional model, was developed by Russell (1980). In this model, emotions are divided along two axes formed by valence (i.e., tone; from pleasant to unpleasant) and arousal (i.e., bodily activation; from deactivation to activation). Emotional words defined by everyday language, such as tension (unpleasant activation), boredom (unpleasant deactivation), serenity (pleasant deactivation), and delight (pleasant activation) can be classified within the dimensional space and correlate to ratios of valence and arousal. Results from EMG are usually placed somewhere along the valence dimension (in correlation with the affect words mentioned before) and EDA results are used as indicators along the arousal dimension. However, there are no clear threshold values for positive or negative valence and the interpretation of psychophysiological measures is usually subjective. There have also been several adaptations of the model (Posner et al., 2005, 2009). Russell (2003) argued that the emotional experience a person feels is a cognitive interpretation of their automatic physiological response. Using affective images and words as stimuli makes a classification of emotions in this model generally more straightforward than using a complex stimulus like a digital game.

Nevertheless, several experiments using psychophysiological analysis of players have been reported using digital games as stimuli (Mandryk et al., 2006; Nacke and Lindley, 2008; Ravaja et al., 2006). In all of these studies certain elements of play (such as collocation of players or challenge level of the gameplay) have been under investigation. In addition to gameplay mechanics or social factors, visual and sonic elements of games influence and shape UX in digital games. Thus, UX in digital games should be analyzed separately for each influencing factor (visual or sonic) if psychophysiological analysis is to yield significant results. By focusing on the measurement of sonic UX and psychophysiology in a game, our goal is to advance the theoretical understanding of UX and sound in digital games. However, one limitation of current psychophysiological studies is that they cannot precisely classify UX in digital games since many experiential phenomena in digital games have no or only fuzzy definitions (e.g., flow, immersion, presence; see empirical study below) and lack standardized quantitative measurements. Hence, one purpose of this study is to provide a correlation between subjective UX estimates (collected with a questionnaire) and physiological data.

1.2. Toward measuring sonic UX in digital games

In digital games, an important part of UX is the conscious design of sound and music to affect aesthetics, feedback and rewards for players (Lord, 2004). Audio signals in digital games guide the interaction within a virtual game world and can be used to provide vital elements of gameplay, such as the interaction feedback in Guitar Hero (RedOctane, 2005). While this sonic UX in digital games may be shaped by sound and music cues, the enticing nature of these stimuli is currently understudied, as is UX in digital interactive entertainment in general. Digital games use the potential of visual information for aesthetic appeal and for elements of game design more than audio information (a few exceptional examples such as Silent Hill 2 (Konami, 2001) or Dead Space (Electronic Arts, 2008) excluded). Our experiment uses game sound definitions defined by Grimshaw and Schott (2008) because they mirror the practice of separate volume controls for sound and music typically found in the console interfaces for the genre of games studied here: references to 'sound' in this study refer to diegetic sound (sound that originates from the game environment, its objects and its characters); references to 'music' refer to the non-diegetic musical soundtrack.

Research has shown that arousal is likely to have a mediating effect on responses to sound, where especially the effect of environmental noise on health and performance has come under scrutiny (Glass and Singer, 1972). Noise was demonstrated to inhibit attention and lead to weak performance while showing an excess in arousal levels. However, the results of sound effects on psychophysiological measures are mixed. Wolfson and Case (2000) report a study, which investigated the influence of color (red/blue) and music volume (loud/quiet) on performance scores, heart-rate, and questionnaire responses. They found that music volume alone had little influence on the psychophysiological and survey measures but the combination of red color and loud music led to perceptions of excitement and successful playing. In another study, Grimshaw et al. (2008) analyzed the effects of audio on UX as well as psychophysiological measures in the FPS game *Half-Life 2* (Valve Corporation, 2004). They treated audio as a single independent variable, using sound and music as different levels of the same variable. However, an one-way repeated-measures analysis of variance (ANOVA) showed no significant results for physiological measures. We assume that a separate analysis of game sound and music could have an effect on psychophysiological variables. Thus, we propose and test the following hypotheses using a 2×2 experimental design with sound (on and off) and music (on and off) as separate independent variables:

H1. When sound is present EMG and EDA levels increase, when sound is absent EMG and EDA levels decrease.

H2. When music is present EMG and EDA levels increase, when music is absent EMG and EDA levels decrease.

In addition, based mainly on Wolfson and Case's (2000) results, we hypothesize about an interaction effect of music and sound on EDA measures:

H3. When both music and sound are present, EDA levels increase when playing a first-person shooter (FPS) game, when both music and sound are absent EDA levels decrease.

IJsselsteijn et al. (2008) theorized that *immersion*, *flow*, *tension*, *competence*, *negative affect*, *positive affect*, and *challenge* are important elements of gameplay experience and developed a Game Experience Questionnaire (GEQ) to assess these elements; this will be used in our study. Preliminary results linking these dimensions