Entertainment Computing 7 (2015) 1–6

Contents lists available at ScienceDirect

Entertainment Computing

journal homepage: ees.elsevier.com/entcom

Modality specific assessment of video game player's experience using the Emotiv ☆

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ARTICLE INFO

Article history:
Received 7 October 2014
Revised 5 March 2015
Accepted 6 March 2015
Available online 17 March 2015

Keywords:
Emotiv EPOC
Video games
Cognitive
Electroencephalographic

ABSTRACT

A growing body of literature has emerged that focuses upon cognitive assessment of video game player experience. Given the growing popularity of video gaming and the increasing literature on cognitive aspects of video gamers, there is a growing need for novel approaches to assessment of the cognitive processes that occur while persons are immersed in video games. In this study, we assessed various stimulus modalities and gaming events using an off-the-shelf EEG devise. A significant difference was found among different stimulus modalities with increasingly difficult cognitive demands. Specifically, beta and gamma power were significantly increased during high intensity events when compared to low intensity gaming events. Our findings suggest that the Emotiv EEG can be used to differentiate between varying stimulus modalities and accompanying cognitive processes.

1. Introduction

Video games represent an immersive activity that is rapidly increasing in popularity. According to the Entertainment Software Association [1], 72% of the general population and 97% of teenagers (between the ages of 12 and 17) reported regular playing of video games. Further, video games have been found to be played more frequently and in more locations [2]. A growing body of literature has emerged that focuses upon assessment of video game player cognition [3–6]. Given the growing popularity of video gaming and the increasing literature on cognitive aspects of video gamers, a growing need is for novel approaches to assessment of cognitive processes occurring while persons are immersed in video game experiences.

1.1. Current approaches to assessment

Assessment of the impact of the video game immersion on the user is often difficult. Numerous studies exclusively employ subjective response questionnaires to draw conclusions about what the participant is experiencing while immersed in virtual environments [7–10]. Self-report data, when used in isolation, are highly susceptible to influences outside the participant's own targeted attitudes [11]. The item's wording, context, and format are all factors that may affect self-report responses [12]. Further, questioning the player while they are playing the video game affects their experience during the video game [13]. While asking them after playing the game can lead to missed information and/or false information [14]. Knowledge of the user-state during exposure to the video game is imperative for development and assessment of video game design [15]. Individuals will invariably have different reactions to a given video game, and without an assessment tool that can be employed online, the researcher will experience difficulties in identifying the causes of these differences, which may lead to a loss of experimental control of the research paradigm.

1.2. Psychophysiological assessment of video game experience

Psychophysiological metrics provide a number of advantages over self-report for enhanced assessment of video game experience [16,17]. The psychophysiological signal is continuously available, whereas behavioral or self-report data may be detached from the gaming experience and presented intermittently [18]. The continuous nature of psychophysiological signals is important for several reasons. First, it allows for greater understanding of how any stimulus in the gaming environment impacted the gamer, not only those targeted for producing behavioral responses [19]. It also follows that a break in the gamer's sense of presence is not necessary, because the signal is measured continuously and noninvasively, and as Slater et al. [20] report, it is even possible that psychophysiological

☆ This paper has been recommended for acceptance by Dennis Reidsma.

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http://dx.doi.org/10.1016/j.entcom.2015.03.001

measures can be used to uncover stimuli in the gaming environment that cause a break in presence. It is also important to note that psychophysiological responses can be made without the gamer's conscious awareness, creating an objective measure of the gamer's state, which can include measures of cognitive workload [21–23], varying stress levels [24,25], task engagement [26,27], and arousal [28–30] among others. Additionally, multiple channels of psychophysiological data can be gleaned from various sensors continuously, which further increase experimental control by providing a combination of measures, so that one measure alone is not the sole basis for design decisions [31].

1.3. EEG to isolate specific game events

Recent approaches to psychophysiological computing have applied psychophysiological modeling to interactive video games [32]. Electroencephalography (EEG) provides a means of accessing and recording neural activity, allowing a computer to retrieve and analyze information from the brainwave patterns produced by thought. EEG has been shown to have the capability to measure player experience [33,34]. Beta rhythm has been shown to increase with attention and vigilance in general [35,36] and during video game play specifically [37]. Salmin and Ravaja [37] used EEG to isolate specific game events from the EEG data. Using Super Monkey Ball 2 as their test platform they were able to detect changes in the brain wave bands as different event occurred during game play. Nacke et al. [38] also showed that EEG data could be used to determine player experience across entire level designs. Using a Half Life 2 mod they measured EEG across three different levels of designed to induce boredom, immersion, and flow. The data showed that there were increased levels of brain wave activity as the player moved across the levels. Further, gamma has been found to be involved in a host of other cognitive processes: attention, arousal, object recognition, and top-down modulation of sensory processes [39]. Beta activity, gamma activity and perceived action possibilities have been found in studies of virtual gaming environments [40,41].

Whilst there are many beneficial EEG applications, much of this technology has yet to leave the research lab. One large factor of this is due to the EEG devices. The majority of research and medical EEG devices are expensive, bulky, and require a number of skilled technicians. As technology progresses, the cost and size will continue to decrease. Recently some inexpensive consumer-grade devices have become available. An example of this is the Emotiv EPOC, a compact, wireless headset that requires comparatively little effort to set up and allows much greater flexibility and mobility than traditional EEG. The EPOC was aimed at the gaming market, and is not classified as a medical device, though a few researchers have since adopted it for a variety of applications [42–44]. Using the EPOC, researchers can detect facial movements, emotional states, and imagined motor movement.

A number of researchers have used the Emotiv EEG recordings for assessment of cognitive processes. Researchers have investigated different EEG processing algorithms to assess classification of shapes being thought about [45], detection of hand movement intentions on the same side of the brain as the hand [46], classification of positive and negative emotion elicited by pictures [47–49], and evaluation of cognitive workload [50].

It is important to note that some have questioned "what" the Emotiv EEG is actually measuring [51], and it is known that the Emotiv sensors detect EMG along with EEG data. Nevertheless, the system has been found to work well for detecting events when the participant is told to picture various stimuli [45,52]. Although the Emotiv EEG does not have the fidelity of a laboratory EEG it still offers the ability to provide a gamer's brain wave signature. Duvinage et al. [53] compared the Emotiv headset to the Advance Neuro Technology (ANT) acquisition system during a run with the P300 speller system. Although the Emotiv headset was not found to be as accurate as the ANT system (a medical grade device), it was able to capture EEG signal at a successful level that was deemed adequate for games. With the benefit of being noninvasive to the wearer, it is a tool that is practical for use by game developers.

The current study aimed to assess the impact of various stimulus modalities on participants using the Emotiv EEG. Specifically, we aimed to (1) assess the impact of various stimulus modalities on participants; and (2) isolate video game events (e.g., death of a character) using the collected EEG data from the Emotiv Headset.

2. Methods

2.1. Participants

EEG data was collected from 30 healthy participants (66% female, mean age = 20.87, range 18–43). Participants were recruited from undergraduate graduate schools; education levels ranged from 13 to 20 years. Ethnicity was as follows: Caucasian ($n = 20$), African American ($n = 1$), Hispanic ($n = 4$), Native American ($n = 1$), and Asian Pacific ($n = 4$). Participants reported they used a computer at least once every day with 30% saying they used the computer several times a day. 66% participants rated themselves as experienced, 27% rated themselves as somewhat experienced, and 7% rated themselves as very experienced when ranking their computer competency. Homogeneity of the sample was found in that there were no significant differences among participants relative to age, education, ethnicity, sex, and self-reported symptoms of depression. Strict exclusion criteria were enforced to minimize possible confounding effects of comorbid factors known to adversely impact cognition, including psychiatric conditions (e.g., mental retardation, psychotic disorders, diagnosed learning disabilities, attention deficit/hyperactivity disorder, and bipolar disorders, as well as substance-related disorders within 2 years of evaluation) and neurologic conditions (e.g., seizure disorders, closed head injuries with loss of consciousness greater than 15 min, and neoplastic diseases). All participants were right handed and had at least average computer skills. Game playing skills ranged from casual cell phone games to playing every day on a personal computer or a game console. The participants received class credit for their participation in the study.

2.2. Apparatus

2.2.1. Super Meat Boy

Super Meat Boy [54] is a platform game in which players control a small, dark red, cube-shaped character named Meat Boy. The participant played a cube of meat jumping around the level to avoid saw blades to reach their goal of rescuing bandage girl. This game requires the minimum amount of keys to play (arrow keys and space bar) thus making it easy for any level of gamer to achieve success. Major events in the game include successfully completing a level and dying. Dying occurs from running into spinning saw blades or falling into fire. As the player progresses through the game the levels get increasingly difficult by adding more saw blades and large jumps. Each level is timed as a goal of the game is to get through each level as fast as possible. The core gameplay requires fine control and split-second timing [55]. Primary game events used for this study included: (1) Death events; and (2) "General Game Play". The "Death events" occurred when the participant's character died. Although there are a number of possible ways for a character to die in a game (e.g., the character gets sliced to pieces, or falls into acid, or gets skewered on needles), we sampled from death events related to the character falling into