The Design and Development of Empathetic Serious Games for Dyslexia: BCI Arabic Phonological Processing Training Systems

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Abstract. In this paper, we describe the User Interface (UI) design issues for serious games aimed at developing phonological processing skills of people with specific learning difficulties such as dyslexia. These games are designed with Brain-Computer Interfaces (BCI) which take the compelling and creative aspects of traditional computer games designed for Arabic interfaces and apply them for cognitive skills' development purposes. Immersion and engagement in the games are sought with novel interaction methods; the interaction mode for these games involved mind-control coupled with cursor-based selection. We describe the conceptual design of these serious games and an overview of the BCI software development framework.

Keywords: Brain-Machine Interface, BMI, SpLD, Learning Difficulty, Dyslexia, Brain-Computer Interface, BCI, Usability.

1 Introduction

Serious games have received increasing interest in Human- Computer Interaction (HCI) research [1,2]. Correspondingly, many accessibility researchers have taken up the challenge of establishing how to best design rehabilitation software and remedial software training programs for developing skills of people with cognitive disabilities and learning difficulties [2]. The development of serious games aimed at language processing skills in particular could contribute to the proliferation of immersive and engaging learning experiences for people with learning difficulties such as dyslexia.

Recent studies have shown compelling evidence in how traditional computer games enhance the learning experience [2]. Gamification in rehabilitation software for auditory processing difficulties and specific learning difficulties has been shown to be

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effective with users across of the spectrum of difficulty levels [12, 13]. Exploiting existing novel interaction methods, such as mind-control and adaptation via affective computing, can impact the user experience in serious games by increasing levels of immersion and engagement [3, 5]. These user experiences have the potential to enhance the motivation, maintain the momentum of learning, and assist educators and practitioners in objectively monitoring the progress of the individuals as well as assessing the effectiveness of configurable remedial programs in these serious games [5, 8]. The concept of such emerging technologies, such as Brain Computer Interfaces (BCI) is leveraging the engaging aspect of using brainwaves, to control elements in an immersive environment, to enhance the learning experience [4, 5].

2 Brain-Computer Interaction in Serious Gaming

BCI research is a growing domain of interest for the design and development of assistive technologies, gaming, and applied contexts of affective computing. Much of the prior research in BCI for assistive technologies is aimed at individuals who have physical disabilities that hinder their ability to manipulate tangible controls (e.g. paralysis), attention deficit disorders (e.g. ADD, APD, and ADHD), and developmental disorders. The gaming paradigm is an interesting platform to employ BCI to further assist the aforementioned target user populations through the translation of user's mental activity into game controls and increasing engagement with nocel interaction modalities for the purpose of immersion in learning activities and improved accessibility.

In recent years, games are increasingly being designed with novel multimodal interaction [8, 10]. BCI games in this domain have leveraged the capability of detecting attention to develop the cognitive skills of players such as sustaining attention [10-11]. Studies examining the usability and user experience (UX) of BCI games have suggested increased levels of engagement and immersion in BCI games [14, 15]. However, the inaccuracy and complexity in controlling objects within the games have been noted as challenges for gamers [16]; these difficulties often hinder their ability to progress within the games and demand higher learning curves when compared to traditional modes of interaction.

3 Mind-Controlled Dyslexia Training

An application for cognitive training of phonological processing skills for Arabic-speaking children with SpLDs was developed. The serious game was designed for the Emotiv EPOC headset to detect patterns of brainwaves for controlling the selection mode in the game and to detect levels of basic affective states (e.g. frustration, excitement, boredom), with frustration levels being linked to controls within the game. The two channels of interaction are depicted in the model illustrated in Figure 1.