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Rapid Deployment and Evaluation of Mobile Serious Games: A Cognitive Assessment Case Study

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Abstract

Serious games are proposed as a more efficient and enjoyable way to carry out cognitive assessment. We compare prediction of cognitive ability with a purpose-built serious game and with a similar game built using a game engine. In an experiment conducted with 28 participants, performance on the two games is assessed relative to three cognitive abilities, using two different tablet sizes and two different input methods. The results for the game-engine variant were similar to the purpose-built game, where both games significantly predicted performance on the three cognitive abilities, and were sensitive to the effects of age. Performance on both games was not significantly affected by tablet size or input method. These results support earlier findings that serious games can provide valid cognitive assessment, and they show that game engines can be used to develop serious games for cognitive assessment, cost effectively and without loss of predictive validity.

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1. Introduction

Serious games are games that are designed with a primary focus other than entertainment[1]. Game mechanics, embedded in the interaction between end users and software systems, increase participant engagement while facilitating skill development, learning, or pursuing some other "serious" goal. Among the serious games that have been developed in recent years, many have been designed for use in health care, with goals such as managing juvenile diabetes[2], reducing obesity[3], and coping with asthma[4]. These serious games vary in their design, with genres ranging from role-playing games[2] to puzzles[5]; they are available on different desktop and mobile platforms; and can

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be customizable to the interests of particular users. Yet, they all share the same intent of promoting health-related behavioral change, and educating users, through increased user engagement, consistent use, and systematic interaction between the user and their game "coach" who, having access to game-performance data, can provide relevant feedback and guide the user's game play. Even though games offer tremendous potential, their design is a challenging and their effectiveness is all but guaranteed: users may not find them interesting or enjoyable to play and they may not fully meet their intended purpose (e.g., educating participants). Thus, development of serious games is risky, and the cost of implementing and evolving them through trial-and-error may discourage researchers from fully exploiting their potential. In order to simplify the task of developing new games, researchers at the University of Alberta (Alberta, Canada) have developed PhyDSL-2[6], a game engine for 2D physics-based games. PhyDSL-2 supports the cost-effective development of instances of a broad class of game types through the specification of the game logic and behavior in a game definition file, which gets subsequently transformed to a playable game through a sequence of transformations by the PhyDSL-2 game engine. In the research reported in this paper, we evaluated how a version of the whack-a-mole game developed using the game engine compared with a purpose-built version of the whack-a-mole game developed at the University of Toronto (Ontario, Canada). The aim was to use a serious game version of whack-a-mole for cognitive assessment, to validate the two different versions of the whack-a-mole serious game against standard tests of cognitive functioning and to gain some insight on the relative merits of the two development processes: custom-built versus model-driven.

2. Cognitive Assessments

The goal of our serious game development was to provide a novel and valid way of assessing cognitive status. Changes in cognitive function are part of the normal ageing process[7] and elderly adults tend to exhibit a higher prevalence of age-related cognitive impairments such as dementia, mild cognitive impairment, and delirium[8]. Accurate screening of cognitive impairments can assist in differentiating age-related versus abnormal cognitive decline[9].

Determining a patient's cognitive strengths and weaknesses enables clinicians to estimate their ability to make medical decisions, and to live independently and to plan ahead for future support[10]. In healthcare, there are standard cognitive assessment methods such as the Mini-Mental State Examination (MMSE)[11] and the Montreal Cognitive Assessment (MoCA)[12]. These screening tools are paper-and-pencil based and they require administration by a trained healthcare professional such as a physician or clinical researcher. Current cognitive screening methods are only minimally interactive, creating little in the way of engagement or entertainment, and providing patients with no intrinsic motivation to complete the assessment.

Software suites such as CogTest[13], the Cambridge Neuropsychological Test Automated Battery[14], and Oxford's Cancellation Tools[15] offer computerized versions of traditional cognitive tests. However, in addition to validation issues when moving a test to the computer medium, there is the problem of potential lack of motivation when performing somewhat uninteresting tasks on a computer. Games have been proposed as an enjoyable way to stimulate cognitive activity in elderly users[16] and to improve brain fitness or to preserve cognitive status. However such games do not yet provide validated cognitive assessment, and evidence as to whether they improve broader measures of intelligence is mixed (e.g. [17]). Thus, there remains a need for a validated, game-like screening tool that can be completed rapidly and independently (or with minimal assistance) by patients, thereby empowering, and motivating individuals to take a more active role in assessing their cognitive health.

The Interactive Media Lab at the University of Toronto developed a serious game to assess cognitive ability[18]. The game was developed as part of ongoing iterative design process, collaborating with a clinical team with extensive experience working with elderly adults and with cognitive assessments[18,19]. The serious game mimicked features of the classic psychological Go, No-Go Discrimination Task[20] and was modeled on the carnival game whack-a-mole (Fig. 1). The Go, No-Go Discrimination Task is a measure of inhibition ability, an executive function, which is necessary for the inhibition of behaviors. Previous work by[21] has demonstrated that there are age-related declines in inhibition, thus making this game suitable for an elderly population at risk of age-related cognitive decline. Moreover, we conducted a usability study on the serious game with a young, healthy sample and compared the game's ability to assess cognitive status with validated psychological tests of executive function [18]. The serious

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