



Cognitive screening of older adults using serious games: An empirical study

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ABSTRACT

Objective: The goal of the research is to develop three serious games using

design for the older adult population, in order to evaluate the cognitive performance of older adults. Simultaneously, the games provide information about the cognitive performance of players with neurocognitive pathology that can be used by health care professionals in clinical monitoring.

Subjects and methods: Two groups of adults aged 50 years or more participated in the study. Group 1 was composed of 52 subjects with high cognitive performance attending a cultural academy and a senior university. Group 2 consisted in 51 patients with cognitive impairment recruited in the Old Age Psychiatric Unit of a university hospital. Each participant played the game and was assessed with a widely-used and well validated neuropsychological instrument (Montreal Cognitive Assessment – MoCA). Concurrent validity was tested for each cognitive domain with Spearman correlation coefficient.

Results: Groups 1 (Senior University) and 2 (Hospital) differed in relation to average age (64.8 vs. 76.5), proportion of female gender (80% vs. 74.1%), educational level and occupation. Subjects in Group 1 scored higher in all assessed cognitive domains and in total MoCA score (24.3 vs. 13.5). The overall game performance was better in Group 1 with the Maximum Level and Group 2 the Maximum Level correlated with all cognitive domains except for abstraction.

Conclusions: The research provides a useful case study in the development of Serious Games for cognitive screening, which can be used independently by players, repeatedly, as cognitive exercise. Thus, these Serious Games are relevant tools that can be used as a stimulus supplement (exercises) and continuous evaluation (normative tables) of the evolution of the players (older adult population), offering useful information (collecting and choosing the data to be analyzed) for follow-up by professionals involved in patient care.

1. Introduction

The difficulties encountered in obtaining materials, validating products and personnel training, as well as the need for new approaches to rehabilitation and teaching healthy habits, make computer games an important ally of teaching, training, evaluation and simulation for health, benefiting professionals and patients. The use of these games in immersive environments and the inclusion of unconventional devices establish a direct relation with the applications of games, in which the concept of Serious Games can contribute to the motivation of the learning in virtual environments. Johnsen et al. [1] conducted researches that demonstrated effective learning and the transfer of learning to real environments when such applications are used for education, assessment, and training purposes.

It is consensual that an aging population is exposed to a greatest vulnerability due to the biopsychosocial losses that may be associated with the individual aging process. Although it is important to emphasize that individual aging is very heterogeneous, it cannot be neglected because there are physical and cognitive losses that increase with advancing age [2].

The physiological level, all systems of the organism may reflect the

aging of its organs, a phenomenon for which various explanations have been advanced, including the nervous system which is reflected in changes in neurotransmitter levels, cerebral atrophy, cellular alterations, decreased oxygenation and cerebral blood flow, among others [2].

The cognitive skills that are most compromised in older people are processing speed, memory, visuo-perceptive and motor functions, inductive reasoning, and numerical and verbal skills. The protective factors of age-related cognitive decline are summarized in “cognition exercise” and physical exercise [3].

Thus, cognitive decline associated with age does not mean entering a process without return and inevitable demential evolution. The recovery of cognitive functions is possible through the already mentioned “exercise of cognition”, as it is defended by empirical studies that verify that the cognitive training can lead to the recovery of the functions aimed. This possibility may be related to the property of neuronal plasticity (brain capacity to compensate for losses), which seems to remain, although diminished at more advanced ages, throughout life [4]. Thus, cognitive stimulation may be beneficial in both healthy older people and patients with pathologies that affect the brain.

The measures of preservation and recovery of cognitive abilities are

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all the more important as the consequences of their deterioration in neurodegenerative diseases are known. Among these consequences are the devastating effect of cognitive dysfunctions and implications on mental health and even physical health, compromising even survival capacity [5,6].

In short, getting old well goes through the implementation of a lifestyle that keeps the body and mind healthy. For this, involvement in leisure activities that are not too demanding from the physical point of view can contribute greatly [7]. The importance of involvement in physical, mental and social activities in the preservation and recovery of good individual functioning in the elderly is of great relevance [8,9].

Given this state of knowledge, the purpose of this research is to determine whether digital games may be useful as an instrument for stimulating and assessing cognitive performance in older individuals with or without cognitive decline. For this purpose, prototypes were created and data collection and comparative analysis with conventional assessments of cognitive performance (Montreal Cognitive Assessment – MoCA) were performed. Three games were developed, using design for the older adult population, with the intention of simultaneously stimulating and evaluating the cognitive performance of the users in the proposed Serious Games environment. The objectives of the research were: 1) to develop Serious Games that will cognitively evaluate the older adult population; 2) measure indicators that allow health professionals to draw conclusions regarding the performance of players (normative tables); 3) compare the results obtained through the prototype with the traditional methods of evaluation. Thus, the authors of the paper intend to answer the research questions, such as: 1) What factors motivate the use and acceptance of the prototype in the elderly population?; 2) What are the positive and negative aspects of the prototype compared to the conventional mechanisms of cognitive evaluation (MoCA)?; 3) In what way can conventional cognitive evaluation methods be adapted for the design of Serious Games for stimulation and evaluation?

In the second section, the papers related to research are presented. In the third section, it will be exposed the methodology used in the research and the selection process of the sample used in the study. The game design proposal used in research and the conventional cognitive evaluation mechanism (MoCA) are discussed in section four. The results of the sample, the performance of the players and the correlations of the game variable with that of the MoCA are presented in section five. In section six, the discussions of the results are carried out, as well as the analysis of the sample, activated cognitive domains and general analysis of the games as mechanism of evaluation and cognitive stimulation. Finally, the conclusions of the article and future work are presented.

2. Serious games for cognitive activation

Research proposed by Baniqued et al. [10] aims to evaluate the use of video games to improve cognitive functions. The methodology of the work consisted of the group of 209 people (young and adults) being trained using several types of video games during a period of 15 h. Such videogames used were aimed at working in the following cognitive domains: logical reasoning, work memory, attention, episodic memory, speed of perception and executive function. At the end of the training, the authors can conclude that the group did not have a significant improvement in the areas of logical reasoning, working memory, episodic memory, speed of perception and executive function. On the other hand, the authors showed a relevant improvement in the attention domain group. Finally, the authors conclude that more research is needed to determine the real benefits of video games in the cognitive field.

The research conducted by Oei & Patterson [11] aimed to analyze possible cognitive improvements with the use of video games of the action genre in relation to those of other genres. The work methodology consisted of a division of five groups, in which they used various

gaming genres on mobile devices, over an hour a day, on five days a week, during the four week period, reaching a total of 20 h Playable. With the results collected, the authors can conclude that, for the users of the games of the action genre, there was an improvement in the cognitive domains of attention and spatial vision. Already, in the other genre player, there have been significant improvements in the domains of memory and verbal fluency, that is, these results indicate that different gaming genres have positive effects on different cognitive domains. That is, one must select the video games according to the cognitive domain that aims to improve.

The study proposed by Tong et al. [12] aims to test the Whack-a-Mole game in the older population through different platforms, such as Nintendo Wii, Kinect and Tablets. The purpose of the Whack-a-Mole game is to evaluate, cognitively, the elderly population. The methodology of the study consists of a usability study of the Whack-a-Mole game at the University of Toronto, with the participation of 24 healthy people (non-elderly). The authors of the study concluded that the Nintendo Wii and Kinect platforms are not a concern for older players, since the touch-based mobile interface is promising for screening for cognitive impairments. Specifically, experience with the Whack-a-Mole game showed that there is a need to adapt the game to make it usable by people with different levels of manual artifact dexterity.

In continuity with the study, Tong et al. [13] proposed to demonstrate the viability of cognitive evaluation in the elderly populations based on mobile platform games. The methodology of the study was the game in an emergency department of the University of Toronto hospital. The results of the players were correlated with a series of standard evaluations (Mini Mental State Examination – MMSE, MoCA and Confusion Assessment Method – CAM). The authors of the study concluded that this is the first time that a serious game is used for cognitive assessment in an elderly population, followed by a full battery of conventional cognitive assessment methods to correlate the results. Thus, serious games suitable for the elderly population can revolutionize cognitive assessment in clinical settings, making evaluation more frequent, more accessible and more enjoyable.

The research developed by Boletis and McCallum [14] aims to design and develop a serious game for the cognitive health screening of the elderly, that is, evaluate the Smartkuber game and document its development design. The study follows a mixed methodological approach using the In-Game Experience Questionnaire to assess players' gameplay experience and a correlational study to examine the relationship between the Smartkuber and MoCA scores (the study sample was thirteen older adults). The study shows that Smartkuber is a promising tool for cognitive health screening, providing a fun and motivating gaming experience for older players.

The study by Manera et al. [15], which aims to examine the acceptability of the Kitchen and Cooking game, is a serious mobile platform game developed in the context of VERVE (EU project available at <http://www.verveconsortium.eu/>), being a game designed for the elderly population. In this game, a list of activities is employed to evaluate and stimulate executive functions (such as planning skills). Kitchen and Cooking was used by a sample of 21 elderly people (with and without cognitive pathology) for a month. Finally, the author of the study could conclude that the game Kitchen and Cooking is adapted for the elderly population with or without cognitive pathology.

The research of Robert et al. [16] intends to analyze the feasibility, advantages and disadvantages of using Serious Games in patients with Alzheimer's disease in order to provide practical recommendations for the development and use of Serious Games in these populations. The methodology adopted by the authors of the research was not clear, but the authors concluded that the results revealed that Serious Games can offer very useful tools for professionals involved in the care of patients suffering from Alzheimer's. However, more interdisciplinary work must be done in order to create Serious Games specifically geared towards this population. In addition, in order to gain more academic, professional credibility and acceptance, more research will be needed to

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