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Effectiveness of Serious Games for Language Processing Amongst Elderly Population with Cognitive Impairment: A Systematic Review and Meta-Analysis

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Abstract. This article intended to carry out a systematic review on the effectiveness of serious games for language processing among older adults with cognitive impairment. Out of 548 retrieved records, six randomized controlled trials (RCTs) eventually met the eligibility criteria. A meta-analysis of four studies showed that serious games are more effective than no/passive interventions in enhancing language processing among older adults with cognitive impairment (p=0.008). Further, a statistically significant effect of serious games on language processing when compared with conventional cognitive activities and conventional exercises was reported in two RCTs. Other RCTs found that exergames are as effective as computerized cognitive training games in improving language processing. Serious games should be offered or used as complementary (i.e., not a substitute) to the current interventions. For there to be definitive conclusions about the efficacy of serious games on language processing more trials are needed.

Keywords. Serious games, Language processing, Cognitive impairment, Older adults, Systematic reviews, Meta-analysis.

1. Introduction

The world is facing a challenging shift in its' demographics and the older person ratio. According to the World Population Aging Index, it has been reported that the share of the aging population aged 65 and above has spiked by 9% in 2019 [1]. Estimates suggest this to reach 2.1 billion in the year 2050 [2]. As the generation is aging, the population is expected to experience a range of challenges in their well-being and a deterioration in cognitive functions. One of the cognitive abilities that deteriorate by age is language

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processing, a cognitive skill allowing people to understand human communications (e.g., spoken, written, and sign languages) and express or communicate their feeling and thoughts verbally (e.g., speech sounds or written symbols) [3, 4]. A recent study showed that the prevalence of language disorders among older adults (≥60 years) is about 19.3% [1]. Research has suggested a range of interventions to improve language processing among the elderly. One of these interventions is serious games, which are interactive digital games that are played for purposes beyond leisure to improve the users' mental, physical, and social well-being [5]. Several systematic reviews have been conducted to investigate the effectiveness of serious games for language processing among the elderly [6-8]. However, these reviews (1) focused on older adults with no cognitive impairment [7], (2) did not compare the impact of serious games to a specific comparator [6-8], and (3) pooled evidence from non-randomized controlled trials (RCTs) (e.g., pilot RCTs and quasi-experiments) [6-8]. Therefore, we hereby explore the impact of serious games on language processing among older adults with cognitive impairment.

2. Methods

To achieve the above-mentioned objective, a systematic review was undertaken. The search sources included eight electronic databases. Further, we inspected the list of references in the included studies, and we examined studies that cited studies included in our review. The search query used in each database is shown in Appendix 1[2]. RCTs that examined the impact of serious games on language processing among the elderly with cognitive impairment were included. To be more precise, we included studies that assessed using digital serious games regardless of the platform. Any study that employed serious games for purposes other than therapeutic purposes was excluded. Only adults older than 60 years with any type of cognitive impairment were the target population in this review. The target outcome in this review is language processing regardless of the outcome measures. Studies not in the English language or published before 2010 were excluded. The study selection process consisted of three phases: eliminating duplicates, screening the titles and abstracts, and reading full texts. We used the Risk-of-Bias 2 (RoB 2) tool to appraise the risk of bias in the included studies. Study selection, extracting data, and risk of bias assessment were conducted by 2 reviewers independently. The extracted data was then synthesized using two approaches: narrative and statistical analysis. The software "Review Manager" was used to carry out the meta-analysis.

3. Results

548 records were identified from searching the databases. We removed 98 duplicates. In the screening phase of titles and abstracts, 363 articles were excluded. Reading the full texts of the remaining 87 allowed the exclusion of a further 81 publications. The current review included six RCTs in total. Of these, four studies were included in the meta-analysis. The flowchart of the study selection process, study features, population, interventions, comparators, outcome measures, and results of risk of bias assessment are shown in Appendix 2, 3, and 4, respectively.

[2] Appendices are available at GitHub: https://github.com/AHassan2/Language-Processing-Serious-Game-Paper.git

Included studies were further grouped into four categories according to the comparator type: serious game versus control (no/passive intervention), serious games versus conventional exercises, serious games versus conventional cognitive activities, and serious games versus other serious games. Four studies assessed the effect of serious games in comparison with control groups [9-12]. Between the experimental and control groups, two of these four studies did not observe a statistically significant difference [10, 11]. Unlike the other two studies, a statistically significant difference in the language processing was found between the two groups, as measured by the Token test ($p<0.001$), Category Verbal Fluency ($p=0.03$), and Boston Naming Test ($p<0.001$), favoring serious games over no intervention [9, 12]. A meta-analysis was conducted on these four studies (6 comparisons as 2 studies examined the outcome using 2 measures). The meta-analysis demonstrated a statistically significant difference ($p=0.008$) in language processing between groups, favoring serious games over control (standardized mean difference (SMD) 92, 95% confidence interval (CI) 0.24 to 1.60). The heterogeneity of the meta-analyzed studies was statistically significant ($p<0.001$) and considerable ($I^2=88\%$) (Appendix 5).

One study compared the effect of serious games to conventional cognitive activities on language processing and observed a statistically significant difference between the groups ($p<0.001$), favoring serious games over cognitive conventional activities [12]. One study assessed the influence of serious games and conventional exercises (balance training), and a statistically significant difference was noted between the two groups ($p<0.001$), tending to use serious games over conventional exercises [13]. The last study evaluated the effect of a computerized cognitive training game and an exergame, and it showed there were not any statistically significant differences between the groups in the language processing as measured by the Seoul Neuropsychological Screening Battery 2nd edition ($p=0.12$), and Korean–Boston naming test ($p=0.76$) [14].

4. Discussion

This review showed that serious games were more effective in improving language processing among older adults with cognitive impairment compared to no intervention, passive interventions, and conventional exercises. This reviews' findings are inconsistent with that of previous reviews. Specifically, two systematic reviews found no statistically significant effect of computerized cognitive training games on language processing in older adults with cognitive impairment, when compared to other passive and active interventions [6, 8]. Another review showed that exergames are not more effective than passive and active interventions in enhancing language processing among older adults without cognitive impairment [7]. The inconsistency in our findings with our reviews can be attributed to the following reasons: (i) the previous reviews did not compare the effect of serious games with a specific type of comparator (e.g., control and conventional exercises), and (ii) they included pilot RCTs and/or quasi-experiments whereas the current review excluded such studies [6-8]. The current review also found that exergames are as effective as computerized cognitive training games in improving language processing among older adults with cognitive impairment. None of the previous reviews compared the effect of computerized cognitive training games with exergames.

5. Conclusions

Our review showed that serious games have the potential in improving language processing among older adults with cognitive impairment. However, this finding should be cautiously interpreted for several reasons: (i) number of the included studies is small, (ii) of the included studies, none were judged to have a low risk of bias in the "overall bias" domain, (iii) the heterogeneity of the meta-analyzed studies was considerable, and (iv) the sample size in most studies was small. Accordingly, serious games should be offered or used as complementary to the current interventions for improving language processing among older adults, until more robust research is available. Due to the paucity of studies, no definitive conclusions were made about the effect of serious games in comparison with different interventions. Therefore, more studies should be conducted to assess the efficacy of serious games in comparison with different interventions.

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