Critical Review:
Determining the efficacy of using computer-based cognitive training to enhance cognition in individuals with Alzheimer's dementia

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This review critically evaluates the efficacy of using computer-based cognitive training to enhance cognition in individuals with Alzheimer's disease (AD). The review comprises six articles with a variety of methodologies including: informational reviews of the literature, randomized controlled trials, non-randomized clinical trials and single-group studies. The available evidence suggests that computer-based cognitive training can be used to enhance cognition, especially in individuals with early stage AD. Further research is needed to establish appropriate levels of intensity and duration, as well as determine the long-term effects of the intervention and its generalization to an individual's functional life. As the number of individuals affected by AD continues to rise, there will be an increasing need for speech-language pathologists to provide treatment and evidence-based education on the effect of computer-based cognitive training.

Introduction

As the aged portion of the population continues to increase, so does the prevalence of dementia. Dementia affects 17-25 million people worldwide. Alzheimer's disease, the most common form of dementia, accounts for approximately two thirds of this population (Galante, Venturini, & Fiaccadori, 2007). AD is a debilitating, progressive neurodegenerative condition affecting memory, executive functioning skills, visuospatial skills, and language (Nousia et al., 2018). It can lead to significant impairment in daily functioning and substantial barriers to communication.

Given the progressive nature of the disease, specific focus has gone towards developing interventions that preserve cognitive function (Lee et al., 2013). Cognitive training is a guided set of standard tasks designed to replicate specific cognitive functions. Cognitive training programs focus on training attention, episodic and working memory, executive functioning, reasoning, speech/language, and visuo-spatial skills (Klimova, 2016). Each task has various levels of difficulty that can be adjusted according to the patient's needs (Nousia et al., 2018). Cognitive training programs have the additional advantage of obtaining an objective measure of the client's performance and serve as a cost-effective intervention. Previous research examining the effects of cognitive training has shown modest results in slowing the progression of AD (Kanaan et al., 2014).

Contemporary research has started to investigate the efficacy of computer-based cognitive training programs. Researchers have shown that patients undergoing memory training using a computer showed greater improvement in cognitive abilities than a paper-based version of the same program (Nousia et al., 2018).

There remains a debate in the literature regarding the efficacy of using computer-based cognitive training to improve cognition in individuals with AD. This could be due to a lack of studies examining the long-term effects of training (Cipriani, Biahchetti, & Trabbucchi, 2006). Furthermore, the inconsistency in the literature regarding intensity level and duration of training make it hard to determine the effects of this treatment.

Objectives

The purpose of this review is to critically evaluate the efficacy of using computer-based cognitive training to maintain and enhance cognition in individuals with AD.

Methods

Search Strategy

Online databases including: PubMed and Google Scholar were used to locate articles for this review. The following search terms were used:

1. Computer-based cognitive training AND rehabilitation AND Alzheimer's disease
2. {compu* AND cognitive AND (intervention or training)} AND Alzheimer's disease

The search was limited to articles in English. The reference lists of selected articles were reviewed for the inclusion of further relevant studies.

Selection Criteria

Articles selected for this review were required to include individuals with AD who were participating in a computer-based cognitive training program and contain a measure of cognition.

Data Collection

The amalgamation of the selection criteria and search strategies yielded a total of six relevant articles to be included. This review contains one informational review of the literature, two randomized controlled trials, two non-randomized clinical trials and one single group study.

Results

Galante, Venturini, & Fiaccadori (2007) used a single-blind randomized clinical trial to determine the efficacy of using a specific, cognitive rehabilitation software to rehabilitate patients with probable early stage AD and/or individuals with mild cognitive impairment (MCI). There were 11 participants included in the study. Pharmacological regimens were controlled for. The treatment group (n=6) underwent three 60-minute sessions per week for four weeks. Tasks during the session targeted: memory, attention, language, non-verbal intelligence, visual perception, and spatial cognition. The control group (n=5) engaged in semi-structured interviews that matched the frequency and intensity of the treatment group.

Appropriate outcome measures were selected including a neuropsychological battery, activities of daily living scales, geriatric depression scales and a neuropsychiatric inventory. These measures were completed prior to treatment, immediately post treatment, three months post treatment, and nine months post treatment. Appropriate statistical analysis was completed. However, at the nine-month follow-up, only the Mini-Mental State Examination (MMSE) was completed, to specifically measure cognitive impairment (Pezzotti et al., 2008).

Results revealed a cognitive decline at the nine-month follow-up in the control group, but not in the treatment group. Mental state scores were stable for the treatment group across all study test points. The results of the other outcome measures (activities of daily living scales, geriatric depression scales, neuropsychiatric inventory measures) were not discussed.

The follow-up assessment at nine months post treatment allowed for some analysis of the long-term effects of the intervention. Given that individuals with AD and MCI demonstrate different degrees of cognitive impairment (Nousia et al, 2018), the results of this study would have been more compelling had the authors separated individuals with MCI from those with AD.

Overall, this study provides suggestive evidence that computer-based cognitive rehabilitation might help to maintain cognitive function in early stage or mildly impaired patients with dementia.

Nousia et al., (2018) performed a randomized control trial to determine the benefits of using a mostly computer-based cognitive training program on the cognitive performance of patients with early-stage AD. There were 50 participants included in the study. The intervention group (n=25) engaged in 60-minute cognitive training sessions on the computer, supplemented with linguistic exercises using paper and pen twice a week for 15 weeks. The control group (n=25) received standard clinical care.

Appropriate neuropsychological measures were assessed at baseline and within 1 week following the intervention. These outcome measures included: episodic and delayed memory, word recognition, attention, executive functioning, processing speed, semantic fluency, and naming.

Appropriate statistical analysis comparing neuropsychological test mean scores at both time intervals was completed. Results showed that the control group remained stable on most neuropsychological measures, except for delayed memory, which deteriorated. The intervention group demonstrated improvement in all cognitive domains following the computer-assisted cognitive language training intervention.

The design of the study allowed for interpretation of the effectiveness of the intervention. However, the authors did not do a delayed follow-up to determine the long-term effects of the intervention. A longer follow-up period would have provided more information on the impact of the intervention.

Overall, this study provides suggestive evidence towards using computer-based cognitive training to improve cognition in individuals with early-stage AD.

Garcia-Casal et al., (2017) conducted a literature review to examine the efficacy of using computer-

based cognitive interventions to improve cognition in individuals with dementia. The review included: before and after studies, randomized controlled trials and case control studies involving either computer-based or non-computer-based cognitive intervention. Participants (n=5-348) were individuals with any type of dementia. Duration of interventions ranged from one to four days (10-72 hours) per week. Cognition was a primary and appropriate measure for each intervention. An electronic search of 11 different databases, clearly defined search strategies, and clearly defined inclusion/exclusion criteria yielded 12 articles. The method used to search for the articles was appropriate given the study design. The results indicated that cognitive interventions have moderate beneficial effects on cognition in individuals with dementia. Individuals benefited significantly more from computer-based cognitive interventions than non-computer-based cognitive interventions.

This review allowed for a comprehensive examination of the literature. However, the review included individuals in all stages of dementia and with all variants of dementia. It is possible that the effect of the intervention would be dependent on both of these variables, thereby affecting the overall presentation of the literature.

Overall, this review provides suggestive evidence towards using cognitive interventions to improve cognition in individuals with dementia.

Kanaan et al., (2014) conducted a single-group study to evaluate the feasibility and efficacy of intensive cognitive training in patients with early-stage AD (n=21). Each individual participated in computer-based cognitive training for 10 days, over two weeks, with four - five hours of training per day. Sessions targeted various aspects of cognition (working memory, sustained attention, switching attention, and divided attention). Pencil and paper tasks were used to supplement computer-based cognitive training. Standard neuropsychological measures were the primary and appropriate measures of interest, administered at four different time intervals (on the first day of training, last day of training, two months following treatment and four months following treatment). Appropriate statistical analysis was used to determine the effect of the intervention. The results showed that participants significantly improved in most practiced computer-based tasks, except for divided attention, which did not improve with practice. Participants also demonstrated improvement on some unpracticed neuropsychological measures, specifically the MMSE. However, these gains were not maintained at the two and four-month follow-up.

The study design allowed for the interpretation of the effectiveness of a short-term high intensity intervention. However, there is no evidence of long-term carryover of this intervention.

Overall, the results of this study provide suggestive evidence that a short period of high-intensity cognitive training can be beneficial and show immediate, specific improvements in trained and some untrained measures of cognition.

Cipriani, Bianchetti, & Trabucchi (2006) conducted a non-randomized clinical trial with 30 individuals to evaluate the effect of a computer-based cognitive training program. Individuals with AD (n=10) were compared to individuals with MCI (n=10), and Multiple Systems Atrophy (MSA) (n=3). Each patient attended two training programs, with a four to eight week break between programs. Sessions were 13-45 minutes, four days a week, for four weeks. Appropriate standardized neuropsychological measures were used to determine cognitive functions at baseline and following completion of the second program. Appropriate statistical analysis was completed. The results showed that individuals with AD had a significant improvement on neuropsychological measures of memory, perception, and attention. MCI patients significantly improved in working memory and psychomotor learning but not perception. Individuals in the MSA group had no significant improvement at follow-up.

The study design allowed for the intervention effect to be examined in three different disease groups, hinting at the possible need for disease-specific interventions.

Overall, this study provides suggestive evidence, indicating that individuals with AD can show improvements in cognition in both trained and untrained tasks.

Hofmann et al., (2003) conducted a non-randomized clinical trial to evaluate the feasibility of using an interactive computer-based cognitive training program in 28 patients. Individuals with AD (n=9) were compared to those with major depressive disorder (MDD) (n=9) and healthy controls (n=10). Participants completed a number of functional cognitive tasks including: finding a shopping route, buying grocery items, and answering multiple choice questions about these tasks. Participants trained three times per week for four weeks. Appropriate

neuropsychological measures of trained and untrained tasks were taken at baseline, immediately after training, and three weeks after training. Appropriate statistical analysis was completed. The results showed that individuals with AD performed significantly worse on all tasks (trained and untrained) compared to individuals with MDD and healthy controls. Individuals with AD showed improvement in trained tasks only. These results were consistent at the three-week follow-up.

This program was not designed to target specific neurological functions. It would have also been beneficial if the study had assessed generalizability to real-life situations, as they were taking a functional approach to their training.

Overall, this study provides equivocal evidence. The evidence does not provide support for the long-term benefits, or generalization of using this interactive computer-based cognitive training program to improve cognition in individuals with AD.

Discussion

The following critical analysis sought to determine the efficacy of using computer-based cognitive training as a method for enhancing cognition in individuals with AD. Overall, the articles reviewed provide positive support towards using computer-based cognitive training to enhance cognition in individuals with AD, especially in the early stages. Of the articles that evaluated both computer-based and paper/pencil-based approaches, computer-based cognitive training was unanimously superior to the alternative.

Many of the articles showed improvement in trained computer-based tasks. It is possible that this improvement could be due to learning in procedural memory, which is relatively preserved in individuals with AD (Hofmann et al., 2003).

Throughout the literature, there appears to be some consistent limitations that could be explored further in order to determine the extent of the effect of this intervention. Some limitations are as follows:

- The intensity level and duration of treatment was significantly varied in each article, making it difficult to determine the amount most suitable for individuals in this population. Future research should focus on comparing the same treatment at varying intensity levels (massed vs. distributed) to determine the appropriate amount necessary to best enhance cognition. The stage of dementia was also not consistent across the literature. Variability in frequency of intervention, duration of intervention, and stage of dementia make the generalization of outcomes difficult.
- Few follow-up studies were completed at a sufficient length after training, to determine the long-lasting impact of the intervention. Future studies should not only determine the long-term effects of the intervention, but also to determine whether or not the effect of the intervention can be generalized and benefit individuals in their functional life.
- Pharmacological treatment was controlled for inconsistently in literature. Future research should evaluate the combined effect of using computer-based cognitive intervention and pharmacological treatment.

Conclusion

Despite the need for further clinical exploration, computer-based cognitive intervention appears to be a beneficial approach that can be used to improve cognition in individuals affected by AD, particularly in the early-stage.

Clinical Implications

As the number of individuals affected by AD continues to rise, there will be an increasing need for speech-language pathologists to provide treatment and evidence-based education on the effect of computer-based cognitive training. Early identification is especially important, as computer-based cognitive intervention appears to be most effective in the early stages of the disease. Therefore, it is crucial that researchers commit to furthering our knowledge of computer-based cognitive intervention. In a world of advancing technology, computer-based cognitive intervention is a realistic, hopeful, probable option to help reduce the communication barriers associated with this disease.

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