CoDAS
ISSN 2317-1782 (Online version)

Original Article
Artigo Original

Evaluation of the Working Memory Training Program for the Elderly

Avaliação do Programa de Treinamento para Memória de Trabalho em Idosos

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Keywords

Short-term Memory
Elderly
Training
Assessment
Speech, Language and Hearing Therapy

ABSTRACT

Purpose: To investigate the benefits of the Working Memory Training on DVD for the elderly. **Methods**: Sixteen volunteers aged over 60 years (67.43 years on average), without hearing loss complaint nor neurological or psychiatric disorders participated in this study. All participants were evaluated by the MMSE and a dedicated working memory assessment. Among these, four participants, unable to go to the University formed the control group, while the other twelve were included in the experimental group. The participants in the experimental group were exposed to the first three DVDs with exercises, having been periodically reassessed by the dedicated working memory assessment. The control group participants were submitted only to the reassessments at the same periods as the experimental group. **Results**: The assessments of the control group did not present any changes, while those in the experimental group significantly improved their results after exposure to the DVDs. Moreover, the experimental group participants reported the benefits of the training for their daily life activities. **Conclusion**: The present study demonstrates the benefits of the Working Memory Training on DVD for the elderly. These results indicate that the cognitive working memory training may be a promising tool for new longitudinal studies with larger populations.

Descritores

Memória de Curto Prazo
Idoso
Capacitação
Avaliação
Fonoaudiologia

RESUMO

Objetivo: Verificar os benefícios do Treinamento de Memória de Trabalho em DVD para idosos. **Método**: Participaram do estudo 16 voluntários com idade superior a 60 anos (média etária de 67,43 anos) sem queixas de perda auditiva, problemas neurológicos ou psiquiátricos, avaliados inicialmente com o MEEM e posteriormente com a avaliação específica para memória de trabalho. Em seguida, os quatro participantes que não tinham disponibilidade para comparecer à Universidade formaram o grupo controle e os doze restantes foram incluídos no grupo experimental. O grupo experimental foi exposto aos três DVDs que compõem o primeiro conjunto de exercícios e reavaliado com o teste específico para memória de trabalho em intervalos regulares. O grupo controle também foi submetido às reavaliações nos mesmos períodos do grupo experimental. **Resultados**: Enquanto o grupo controle não apresentou qualquer alteração nas avaliações, o desempenho no teste de memória do grupo experimental melhorou significativamente após a apresentação dos DVDs. Além disso, o grupo experimental relatou os benefícios do treinamento para suas atividades cotidianas. **Conclusão**: O estudo demonstra os benefícios do Treinamento de Memória de Trabalho em DVD para idosos, que se revela uma ferramenta promissora para novos estudos longitudinais com populações maiores.

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Received: May 01, 2018

Accepted: October 30, 2018

Study conducted at Mestrado Profissional em Fonoaudiologia, Universidade Veiga de Almeida – UVA - Rio de Janeiro (RJ), Brasil.

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Financial support: CNPq (PQ 312079/2016-8) and FAPERJ (CNE 203.055/2017).

Conflict of interests: nothing to declare.

INTRODUCTION

The elderly population in Brazil has grown significantly, creating a very specific demand for health care services and policies[1]. Healthy aging may include one or more chronic diseases, as long as they are controlled and do not hinder autonomy, social integration, and the maintenance of an active life[2,3]. The prevalence of chronic diseases such as cardiovascular disease, dementia, cancer, sarcopenia, osteoporosis, osteoarthritis, and type 2 diabetes increases significantly with age[4]. Besides, cognitive decline can also be present in healthy aging[5]. Attention, memory, perception, language, and decision-making are among the most affected cognitive skills, which may also be compromised by age advancing[6,7]. Generally, memory decline associated with aging is initially identified in the older adults' difficulty to recall recent information—i.e. it involves what will be discussed in this work as working memory*[8,9], which is responsible for the temporary keeping of information for the performance of cognitive tasks[10-12].

Until recently, it was believed that the brain was like a sealed black box[13] that kept us bound to its innate features. However, in recent decades, research reveals that the human brain may continue to adapt and develop new cognitive skills through old age[11]. This ability to reorganize and create new pathways, called cerebral neuroplasticity[11,14], evinces the potential of working memory training programs to benefit the cognitive performance of the population including the elderly.

Evidences in neuroplasticity motivated the creation of numerous working memory training programs according to the most varied combinations of techniques and tools, including memory workshops, computer training, among others[15,16]. The experimental group performed better than the control group (12.5% on average) and reported having transferred the trained skills to their daily life tasks. However, some formats of these training programs, especially when offered in workshops or personalized care, are inaccessible to most elders, as they are not available nationwide or are too expensive. In addition, the working memory training tools available free on the internet are not widely accessible to the majority of Brazilian elders yet. Furthermore, the elderly often present serious difficulties in using computers[17], not to mention that over 70 million people still have no internet access in Brazil[18].

In face of the difficulty of access by the elderly to the memory training programs available, we designed a new combination of memory training techniques in DVD format, which requires only a TV set and a DVD player, both present in most Brazilian homes. Thus, in an effort to effectively apply basic science findings to the clinical needs, by means of exercises and suggestions of changes in patients' lifestyle, we have developed a set of guidelines and exercises in the form of a Working Memory Training DVD Set for the elderly. The present study applied the training to healthy elderly in order to investigate if the program is able to improve the performance of the participants' memory. The first evaluation of this program is reported below.

* According to Cowan[9], the difference between short-term memory and working memory lies in the fact that the first is activated by subconscious stimulus, while the second involves processing the attentional system and the preservation and handling of information for a short time. In spite of differentiating the two types, the author states that short-term memory is included in working memory. Thus, for the purposes of this article, we use "working memory" as a term encompassing both definitions.

METHODS

Participants

This study was approved by the Research Ethics Committee of Universidade Veiga de Almeida under protocol number 232/09. The participants were recruited by means of a call for volunteers on the Speech Language pathology regional Council website and telephone calls to individuals on a waiting list for participation in an activity program for seniors. The objectives, goals, and detailed development of the project was clarified to all of them on the phone call. Those who agreed to participate were scheduled for individual interviews at Universidade Veiga de Almeida, in Rio de Janeiro, where the work was performed. During the interview, the participants answered a sociocultural questionnaire and signed the Informed Consent Term.

Sixteen healthy older adults, native speakers of Brazilian Portuguese, aged over 60 years (average age of 67.43 years) were included in the study.

Exclusion criteria

The following exclusion criteria were used:

(i) neurologic impairment; (ii) alcoholism; (iii) prior psychiatric treatment; (iv) untreated visual or auditory impairment; (v) prior exposure to memory stimulation. The Mini-Mental State Examination (MMSE) was applied to exclude participants who presented suggestive signs of dementia or cognitive decline. The elderly patients with scores equal to or greater than 26[19] were considered eligible for the study.

Criteria for inclusion in the control and experimental groups

Selection of the four participants in the control group was based on the individuals' interest in taking part in the research and their unavailability to change their routines in order to attend Universidade Veiga de Almeida twice a week, for two months, in addition to the researchers' availability to go to their homes to perform the assessment. In this way, individuals presenting characteristics very similar to those of the experimental group, according to the sociocultural questionnaire, were included as per the same inclusion and exclusion criteria. The same assessments were applied to the experimental and control group, maintaining the criteria and procedures—i.e. the latter were assessed in the same week as the participants of the experimental group. During the study period, they did not receive nor participate in any activity focused on memory stimulation. Among the twelve participants of the experimental group, eleven were female and one was male.

The participants in both groups present the following characteristics in common: they are non-smokers; the majority is composed of retirees dedicated to household activities, with regular use of medication, all under medical follow-up; half

of them did not present any memory impairment complaints, whereas the other half presented mild complaints that did not hinder their activities.

After application of the exclusion criteria, the participants presented fairly similar characteristics: the majority was between 60 and 69 years old, with over 12 years of schooling, presenting MMSE scores above 27 (mean score of 28.06, Cf. Table 1).

Application of memory training and assessment of participants

The twelve participants in the experimental group were exposed to the Working Memory Training DVDs for the Elderly[15], which is composed of three DVDs. The first contains three modules with information about memorizing techniques and practices and lifestyles that are beneficial to memory. The second and third DVDs contain a set of five modules each with practical exercises in increasing degrees of difficulty, from the basic to the advanced module. The exercises include strategies to memorize numbers—e.g. addresses, phone numbers etc.), people's names, lists (e.g. shopping lists)—and to identify hidden pictures in images, among others. At times, the DVD instructs participants to write down the items memorized in previous tasks. For instance, in a sequence of tasks, the participants were asked to memorize a list of ten words displayed for one minute and then the names of ten people who say their names (where each face is displayed for 30 seconds). Afterwards, the DVD prompts them to write down the words from the list displayed at the beginning. Thus, if the list had ten words, they will know how many they were able to recall. Although these notes allow each participant to control their scores, we decided not to analyze them in order to prevent potential distortions. The cognitive skills stimulated are related to the working memory modules proposed by Baddeley[10]. Among them, selective attention, visuospatial perception, language, and processing speed stand out.

During the months of May and June 2010, an assessment consisting of four computerized tests dedicated to working memory was performed, where tests were interspersed between exposure to the modules of the first two DVDs. The tests were elaborated and kindly provided by the team of Professor Rogério Panizutti, from Universidade Federal do Rio de Janeiro. The computerized test consists in the display of two lists of words, one for memorization, preceded by a yellow rectangle, and one for evocation, preceded by a yellow triangle. The center of the monitor shows a cross, at which participants are asked to stare while the words are displayed for three seconds. Beforehand, each participant, using headphones with a microphone, takes a short training session with a list of ten words for memorization and ten for evocation. Then, the test is applied with another list of thirty words for memorization paired with thirty others for evocation. For each word displayed on the evocation list, the volunteer should respond verbally "Yes" or "No" to indicate if the word from the evocation list was present in the memorization list—i.e. the participant performed a task to recognize the memorized words present in the evocation list. The tests were performed individually on a previously scheduled date and time and the DVDs were played to the entire group in a classroom with audiovisual equipment. The experimental group attended two weekly meetings for exposure to memory training and assessment. The assessment lasted approximately 15 minutes and exposure to the modules ranged from 14 minutes and 20 seconds to 53 minutes and 52 seconds. On assessment days, there was no exposure to the DVDs.

Each participant received a notepad and blue ballpoint pen to use as requested by the DVD at the moments of evocation. They were asked to sit separately, without the possibility of interaction during exposure to the DVD. Altogether, there were twelve meetings (two per week) with participants, of which four consisted in assessments and eight, in memory training. The tests were performed at the first, fifth, ninth, and twelfth meetings.

Chart 1. Stimulation sessions and assessment distribution

Date	Event
14/05/2010 (Friday)	1st memory assessment (Memory test)
17/05/2010 (Monday)	1st training session (explanatory)
21/05/2010 (Friday)	2nd training session (explanatory)
24/05/2010 (Monday)	3rd training session (explanatory)
28/05/2010 (Friday)	2nd memory assessment (Memory test)
07/06/2010 (Monday)	Basic training module
11/06/2010 (Friday)	Training module: moderate level
14/06/2010 (Monday)	Training module: Intermediate level
18/06/2010 (Friday)	3rd memory assessment (Memory test)
21/06/2010 (Monday)	Training module: difficult level
24/06/2010 (Thursday)	Training module: advanced level
29/06/2010 (Tuesday)	4th memory assessment (Memory test)

Dates of training and assessment sessions. It is possible to depict the gaps between them as experienced by the participating elderly in the program

Table 1. Participants features

Features		Control (n=4)	Experimental (n=12)
Age	60-69	100%	66.67%
	> 70	-	33.33%
Schooling (years)	< 10	-	25%
	12-13	25%	41.67%
	16-20	75%	33.33%
Memory complaints	Absent	50%	58.33%
Physical activity	Present	50%	33.33%
Mini Mental	26	-	16.67%
	27-28	75%	58.33%
	29-30	25%	25%

Volunteer distribution percentage by feature investigated and performance in the Mini Mental State Examination. The majority of participants were under 70 years old, had no memory complaints and scored higher than 27 in the MMSE. Moreover, all control group members had over 16 years of schooling

Chart 1 shows the distribution of stimulation and assessment sessions. At the end of the study, the researchers offered copies of the DVDs to all participants as a token of appreciation for their time and effort.

RESULTS

The memory test responses were tabulated and recorded with software Presentation (Neurobehavioral Systems, 14.5 demo version of 1/4/2010) installed in a laptop. The responses, which were in audio file format, were later analyzed by a software developed by the second author of this study. It used the Matlab language and the HMM (Hidden Markov Models) technique to recognize "Yes" and "No" patterns. The software recognized the sound pattern recorded on the audio files by the HMM technique, one at a time. Afterwards, all of the responses were recognized, the audio files were manually checked for correction of the HMM method errors. The software SPSS 15.0 for Windows, Release 15.0.0 (6 Sep 2006), was also used to generate the score percentage of each participant.

The results were treated to exclude outliers positioned at two standard deviations from the mean. Intragroup comparisons (Control and Experimental) were made by means of the Prisma GraphPad software (GraphPad, Inc. 5.00, 2007 version). In the control group, the presence of improvement would indicate learning from the memory test, while in the experimental group, the comparisons would allow verification of the effects of the different stages of stimulation on the participants' performance. After applying the Kolmogorov-Smirnov normality test, it was found that the data of both groups were parametric. Thus, the ANOVA test was used for multiple comparisons of parametric data. The analysis was one-way, as there was a single variable to be studied (in this case, if memory performance improved or not), with $\alpha < 0.05$. For comparison of the assessments, two by two, Tukey's post hoc test was used. The correlation between the participants' performance in the two tests used in this study—namely, the MMSE and the memory test—was determined by Pearson's test, used for parametric samples, with statistically significant p values equal to or less than 0.05.

Figure 1 shows the memory test results

The individuals in the control group were exposed only to the assessments applied to the experimental group in order to exclude the possibility of learning from reapplication of the memory test. The individual participants' scores remained relatively stable, showing no improvement in performance over the course of the assessment (Figure 1) and, therefore, no learning effect. Upon comparison, the test results did not present statistical difference (one-way ANOVA test followed by Tukey's post hoc test, $F_{3,12} = 1{,}553$, $R^2 = 0{,}3738$, $p = 0.9242$).

Although all participants were asked to respond to each new word that appeared on the screen during the memory test assessments, several participants in the experimental group did not provide a sufficient number of responses to produce a score

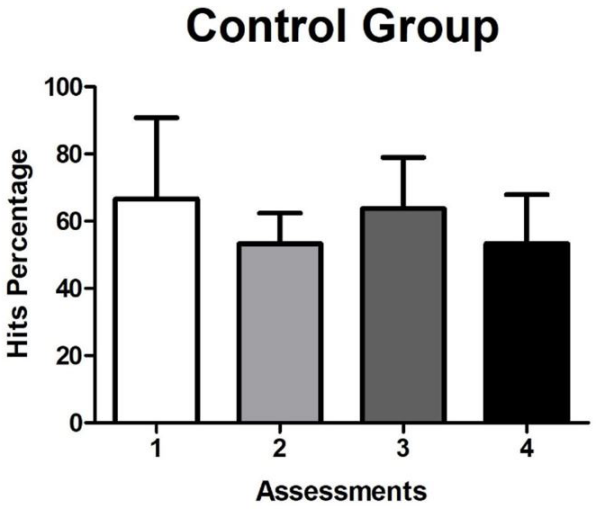

Figure 1. Performance of the four participants. Percentage hit averages with respective standard deviations. The variation in volunteers (n=4) responses guaranteed the absence of significant differences among assessments. This indicates the absence of an effect of learning by test repetition. One-way ANOVA with post- test Tukey, $F_{3.12} = 1.553$, $R^2 = 0.3738$, $p = 0.9242$

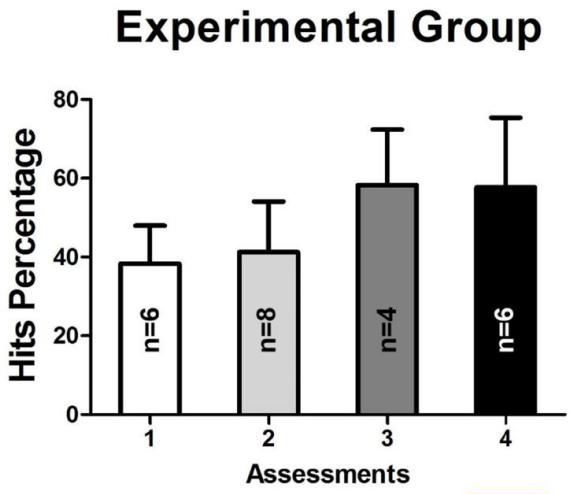

Figure 2. Experimental group performance through four memory assessments. The columns contain average percentage of hits and number of participants analyzed in each assessment (n) with respective standard deviations. Volunteers' performance show significant improvement. One-way ANOVA with Tukey's post-test, $F_{3.20} = 3.376$, $R_2 = 0.3362$, $p = 0.0386$

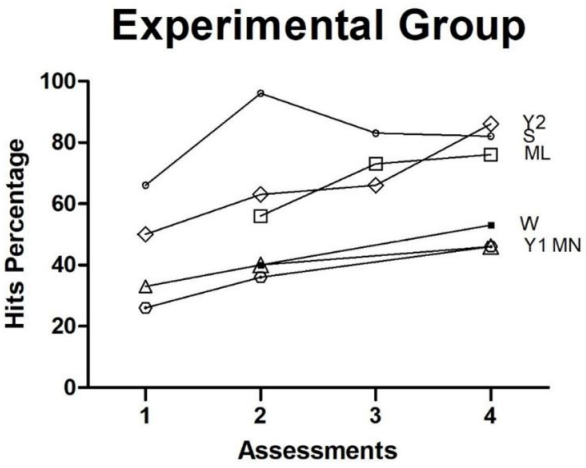

Figure 3. The evolution of six participants throughout the study. Each line with its respective symbol corresponds to one participant identified by name initial followed by a number, in case of coincidence (Y1, Y2, ML, MN, S and W). Not all got results in all the assessments

percentage. Thus, the results of some evaluations presented gaps that hindered the performance of paired statistical comparisons in the experimental group. In view of these facts, the statistical analysis was carried out based on the results of individuals per assessment, so that each evaluation not always computed the results of the same volunteers. Comparison between the evaluations revealed that, in general, there was a significant improvement in the performance of the volunteers (one-way ANOVA test followed by Tukey's post hoc test, $F_{3,20} = 3.376$, $R^2 = 0.3636$, $p = 0.0386$, Figure 2).

All participants in the experimental group who obtained a percentage of response in the first or second assessment showed improvement compared to the results obtained in the fourth assessment. However, improvement was clearer in six out of eight participants (Figure 3).

The Pearson's test revealed no correlation between the participants' performance (control group, $p = 0.248$ and experimental group, $p = 0.419$) in the memory test and the MMSE.

DISCUSSION

The effects of the working memory training program were reported by volunteers from the experimental group during sessions of exposure to the DVD. All of them seemed interested, as they wrote down the mnemonic strategies explained in the sessions and reported that they were applying the knowledge acquired to their daily life activities. Other studies also indicate that the benefits of working memory training are perceived in the volunteers' daily lives[16]. Additionally, the choice of the DVD format has great chances of success in Brazil, as a European study, which used a memory training program for older adults over 60 years old, available on interactive TV sets, presented excellent results[19]. However, the study proposes training in a format similar to the videogame, which is accessible at home only for those who have an interactive television. This means that the user needs to react and know how to operate the TV in order to perform their training. Nevertheless, nowadays not all Brazilians have access to this technology, although it will soon be present in most households in the country.

In 1994, Bertolucci et al.[20] translated and adapted the MMSE for the Brazilian population. In this study, the authors exclude the influence of participants' age, but take into account the influence of educational levels on the volunteers' performance in the test. Based on the educational levels, a score > 26 was established as a cutoff point for a high educational level (eight or more years). A few years later, Almeida found an influence of age and schooling on the performance of patients from a mental health clinic in the MMSE[21]. In his 1998 study, Almeida established 23/24 as the most adequate cutoff point as to the specificity/sensitivity ratio for patients with mental disorders over 65 years old and with some schooling, bracketing individuals with an educational level ranging from primary school to college. Based on this information and the study by Bernier *et al.*[22] and considering that, in the present study, all of the volunteers presented good mental health and that the majority had a high educational level, the cutoff point of the selected MMSE was > 26. Although the study by Netto *et al.* [23], performed with healthy elderly individuals with a high educational level, set the cutoff point to > 24, the study participants had a mean score of 28.11, very similar to the score found in the present study[28,06].

The similarity between the participants in the control and experimental groups allowed us to make categorical inferences about the possibility of learning from the reapplication of the

working memory assessment. Although the four participants in the control group have not attended the socialization activities at the University, as recommended in the literature[15,23], they all had a very active social life and few memory complaints, mastered their daily life activities, and were involved in activities with younger people. Even so, the performance of the control group in the memory assessments remained stable and without any significant difference, which excludes the possibility of learning from the memory assessment.

In view of the elderly's difficulty in dealing with computers and the lack of internet access in many regions of Brazil, in addition to the popularity of TV sets and DVD players, the Working Memory Training DVD for the Elderly[15] seems to be a promising tool in terms of reaching out to most of the country's older population. In addition, the two sets of training exercises provide continuous stimulation of memory in case the elderly experience difficulties in their daily tasks after the end of the first set of exercises.

Despite the promising results, the present study faced limitations. Some individuals had a difficult time reacting to the computerized memory test stimuli. Although the DVD was designed to allow the user to improve their performance by watching each exercise module as many times as they wish, the participants did not have this option. The fact that the training was applied by the researcher, although she did not provide any additional information about it, created an artificial situation in relation to the DVD training proposal.

CONCLUSION

The present evaluation of the Working Memory Training Program for the Elderly indicates that the practice of the exercises contained in the DVD improved the performance of the participants' working memory. Thus, it is inferred that cognitive training may consist in a positive alternative for the improvement of the individuals' working memory during the stimulation period.

Although there is strong evidence that working memory neuroplasticity lasts for a lifetime, future longitudinal studies with more volunteers can confirm the benefits reported here and test their stability in the long term.

Considering the dimension of Brazil and its socioeconomic situation, the use of a physical media such as the DVD potentially becomes a very promising tool to disseminate improvements in the memory conditions of the elderly population.

ACKNOWLEDGEMENTS

We would like to thank Professor Rogério Panizutti (UFRJ) for granting us access to the Working Memory Assessment.

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Author contributions

VVB worked with the volunteers; AGM and AIF are the Professors who elaborated the working memory assessment; MM co-authored the Working Memory Training Program and supervises VVB's research.