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MEMOREX: Development and initial evaluation of a computer game for cognitive training of the elderly*

MEMOREX: Desenvolvimento e avaliação inicial de um jogo computadorizado para treinamento cognitivo de idosos

MEMOREX: Desarrollo y evaluación inicial de un juego informatizado para entrenamiento cognitivo de ancianos

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Sabrina Martins Barroso[1]
Maria Gabriela Longo[2]
Ana Laura Domingues de Sousa[3]
Larissa da Costa Formaji[4]
Larissa Lacerda Diniz[5]

This is a development study carried out between 2018 and 2019, in the city of Uberaba. It aims to develop a game for cognitive training, called Memorex, and to conduct the initial assessment of its effectiveness with elderly people from the community. The research was divided into 2 stages: creation of the game and verification of its efficiency. It was developed at first as an electronic game with seven cognitive tasks, which allows to characterize the player and generates a usage report. The suitability of Memorex was assessed by two expert judges. After its creation, 58 elderly people were evaluated, divided between experimental group and control group. There was a pre-test and post-test evaluation of cognitive aspects. There was cognitive improvement in the elderly who underwent the post-test intervention when compared to the elderly who did not receive said intervention, showing the usefulness of Memorex as cognitive training and its potential for use with the elderly.
Descriptors: Practice, Psychological; Cognitive aging; Video games.

Este é um estudo de desenvolvimento realizado entre os anos de 2018 e 2019, em Uberaba, com o objetivo de desenvolver um jogo para treinamento cognitivo, chamado Memorex, e realizar a avaliação inicial de sua efetividade com idosos da comunidade. A pesquisa foi dividida em duas (2) etapas: criação do jogo e verificação da sua eficiência. Inicialmente foi desenvolvido um jogo eletrônico com sete tarefas cognitivas, as quais permitem caracterizar o jogador e geram um relatório de uso. A adequação do Memorex foi avaliada por dois juízes especialistas. Após sua criação, 58 idosos foram avaliados, sendo estes divididos entre grupo experimental e grupo controle. Houve avaliação pré e pós-teste de seus aspectos cognitivos. Verificou-se no pós-teste melhora cognitiva dos idosos que passaram pela intervenção em relação aos idosos que não receberam intervenção, mostrando a utilidade do Memorex como treino cognitivo e seu potencial para uso com idosos.
Descritores: Prática psicológica; Envelhecimento cognitivo; Jogos de vídeo.

Este es un estudio de desarrollo, realizado entre los años 2018 y 2019, en Uberaba, con el objetivo de desarrollar un juego para el entrenamiento cognitivo, llamado Memorex, y realizar la evaluación inicial de su eficacia con miembros ancianos de la comunidad. La investigación se dividió en 2 etapas: creación del juego y verificación de la eficiencia. Inicialmente, se desarrolló un juego electrónico con siete tareas cognitivas, que permite caracterizar al jugador y generar un informe de uso. La adecuación del Memorex fue evaluada por dos jueces expertos. Después de su creación se evaluaron 58 ancianos, divididos entre el grupo experimental y el grupo de control. Hubo una evaluación de los aspectos cognitivos antes y después de los testes. Se verificó una mejora cognitiva de los ancianos que pasaron por la intervención en el post-test en comparación con los ancianos que no recibieron la intervención, lo que demuestra la utilidad del Memorex como entrenamiento cognitivo y su potencial de uso con los ancianos.
Descriptores: Práctica psicológica; Envejecimiento cognitivo; Juegos de video.

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1. Psychologist. Specialist in Psychological Assessment and Human Development. Master in Psychology. PhD in Public Health. Adjunct Professor at Universidade Federal do Triângulo Mineiro. Uberaba, MG Brazil. ORCID: 0000-0003-1759-9681. E-mail: smb.uftm@gmail.com
2. Psychologist. Specialist in Behavior Analysis by Universidade Federal de São Carlos. Uberaba, MG, Brazil. ORCID: 0000-0003-0264-2544 E-mail: mariagabrielalongo@hotmail.com
3. Psychologist. Self-employed professional. Ribeirão Preto, SP, Brazil. ORCID: 0000-0003-3017-5162. E-mail: domingues231@gmail.com
4. Undergraduate student in Psychology at UFTM, Uberaba, MG, Brazil. ORCID: 0000-0001-8851-2120 E-mail: larissaformaji@hotmail.com
5. Undergraduate student in Psychology at UFTM, Uberaba, MG, Brazil.. ORCID: 0000-0002-5149-5272. E-mail: la.ladi@hotmail.com

INTRODUCTION

Population aging is accelerating in most societies. It is estimated that, in 2050, the elderly will represent 22% of the world population[1]. In Brazil, there was an increase from 15.5 to 23.5 million Brazilians aged 60 or over in the period from 2001 to 2011, with an increase in the population aging index from 19.8% to 30.7%, between 2000 to 2010[2].

The increase in the elderly population intensified interest in the development of ways to maintain the cognitive capacity and quality of life of people in this age group. Age-related cognitive decline begins throughout adulthood and accelerates with the advance of the years[3]. Some people experience milder losses, which do not compromise their life activities, others experience cognitive impairment in specific functions and there is also a group of people who will develop some form of dementia. Cognitive impairment and dementia represent an increased risk for the elderly, as cognitive function is a key element in the ability to process information in everyday life, and a deficit in such functions impairs their autonomy and quality of life[3].

Among the skills that contribute to functional independence are the perception of environmental clues, planning capacity and memory. Visual perception is related to the processing of visual stimuli as a way of understanding the physical world and the integration of vision with other senses[4]. This ability contributes to the perception of the environment, so that the information can be systematized and used intentionally.

The ability to intentionally shape one's behavior is part of planning. This planning collaborates to define objectives and establish the best way to achieve them, taking into account possible instruments, steps and tasks, inhibiting behaviors or selecting the most appropriate ones to achieve goals[5]. While memory represents the capacity to acquire, store and evoke information[6,7].

In order to prevent decline, and assist in the rehabilitation of impaired cognitive functions, cognitive training programs have been developed[8,9]. Participation in training has shown learning effects[7] and changes in neural systems and brain plasticity[10]. These effects have been more studied in young people[7,11,12], but investigations also indicate the positive effect of cognitive training with the elderly[13-15].

Studies indicate the existence of cognitive training mediated by technology and conventional[4]. Among the trainings that adopt technological tools, games have shown high potential as a form of cognitive intervention[16]. A longitudinal study that followed 3777 elderly people for more than 20 years showed that board game players have a 15% lower risk of developing dementia when compared to non-players, and these effects were maintained even up to two decades after collecting the baseline[17]. Electronic games bring similar results, pointing out that players have improved visual attention, problem solving skills, cognitive flexibility, episodic memory, working memory and spatial orientation when compared to non-players[14,16,18].

Electronic games can be defined by promoting human interaction with an electronic device, through a user interface that produces visual and auditory feedback. They can also be classified into different categories, which are: "serious games" that aim to spread information or a learning experience for the player; "Educational games" like *Treinamento Cerebral* and Brain Age; "Simple games" or non-action and "complex games". Cognitive training with electronic games has an advantage over traditional training, as they are relatively cheaper and ludic, including planned items of image, movement, sound and feedback, proving to be much more striking and rewarding than printed material[14].

When investigating cognitive training for the elderly involving games, there was a lack of material in the Brazilian context[19] and that many training programs do not assess the validity of their tasks[20,21]. Considering the importance of games as a form of cognitive training for the elderly[17,22], this study aimed to present the process of developing the game for cognitive training

"Memorex" and the initial assessment of its effectiveness as an intervention with community elderly.

METHOD

This work is a developmental and exploratory research of validity and effectiveness, which was carried out throughout 2018 and 2019, at Universidade Federal do Triângulo Mineiro, in Uberab, Minas Gerais state. It was divided into two stages: 1) Developing Memorex; 2) Initial assessment of the effectiveness of the game. The project was approved by the Research Ethics Committee (CAAE 04450818.8.0000.5154) and all participants signed the informed consent form. All elderly people received a report with their test results.

Stage 1 - Developing Memorex

Initially, publications on computerized cognitive training used with the elderly and in the app stores (Apple Store and Play Store) were searched for games available that claimed to train cognitive aspects.

From these previous surveys, it was defined that the new game created: 1). It would be developed for Android platform and Windows system; 2). It would use multiple sensory stimuli, especially image and sound; 3). I would adopt a customizable avatar, for greater identification with characters; 4). It would include a reward and feedback system to increase users' motivation[8]; 5). It would adopt progressive difficulty of levels, but it would have a system of return to an easier level with two consecutive errors[23]; 6). It would provide a usage report to monitor the player's evolution and measure training efficiency.

After defining the tasks, the research team made a prototype of Memorex programming. The creation of the initial images and programming was done by two undergraduate students and then improved by a contracted programmer. When the first executable version of the program was ready, it was subjected to expert evaluation to verify the adequacy of tasks and stimuli.

Two judges were invited, and both worked on the analysis and analyzed the material independently. The invited judges were a man and a woman, with experience in cognitive intervention with the elderly. Both were doctors in Psychology or Neuroscience and had a minimum professional experience of 5 years.

The judges received the invitation for the survey by email and, after accepting it, received a spreadsheet to be filled out and an executable version of Memorex for computer and another for smartphone. The judges were asked to indicate whether the screens were friendly for an elderly player (yes or no), their belief in the capacity of tasks such as training the indicated functions (non-existent, low, reasonable, elevated), if they considered it important to include some other item in tasks (yes or no), if there was differentiation in gameplay when they did it by computer or smartphone and, if so, which item (open answer) and a field for general comments and items not covered in the previous topics.

The judges' responses were analyzed for content and accepted when there was agreement between them, assessed using the Kappa coefficient. In case of disagreement, the research team discussed the suggestions and decided on a case-by-case basis whether to accept the suggestions received. The work of creating images was divided between the research team and a contracted programmer. Memorex programming was initially done by the research team and then reviewed and adjusted by the programmer. The version delivered by the programmer was considered as the final version of Memorex and adopted for Stage 2.

Stage 2 - Initial assessment of the effectiveness of the game

Elderly people participated in the study in an equal proportion in two groups, namely: G1 - elderly people who trained with MEMOREX for three months; and G2 - elderly people who did not receive any intervention. The elderly were invited among the attendees of the Universidade Aberta a Terceira Idade, the Social Service of Commerce and the Elderly Care Unit in the city of Uberaba - MG.

The Rey–Osterrieth Complex Figure Test (ROCF) was used. It was created in 1941 by André Rey and revised in 1944 by Osterrieth and validated for Brazil[24]. The ROCF is composed of a complex, geometric and abstract figure, presented for copying at the first moment and that must be reproduced by memorization at the second moment5.

The Clock Drawing Test (CDT), developed by Crichley, in 1953, was applied and used frequently to track deficits in memory, motor function, executive function and verbal comprehension. Its application involves two stages, in the first one the participant is asked to drawn an analog clock without an exposed model, pointing to a specific time. The evaluator then draws a watch and asks the participant to copy the model. Its correction was based on the five-point criterion[25].

The Face Memory Test (FMT) also used here. The FMT was validated for Brazil[26] to assess short-term memory based on the ability to remember faces present in the test and their respective information (name, surname, profession and city of origin).

The Pictorial Recognition Memory Test (PRMT), created in 2007[27], was used. It consists of assessing the visual memory capacity from the presentation of a card with 55 pictures that must be memorized.

We adopted a sociodemographic and clinical questionnaire that included questions about age, gender, educational level, visual, physical, emotional and cognitive problems, color blindness, medication used, memory complaints and a list of 10 words for immediate recall (presented 3 times in distinct order). This list was requested to be retrieved from memory after FMT was performed, as a measure of long-term memory.

When the final version of Memorex was ready, the research team received training to apply the instruments and invited the elderly to participate. A first evaluation (pre-test) was carried out, in which Memorex was installed on the elderly's mobile phones and computers and, after three months, there was a new evaluation (post-test).

The pre-test took place between December of 2018 and February of 2019. A schedule was elaborated with the elderly, clarifying the work proposals, collecting the signature on the Free and Informed Consent Term (ICF) and applying the evaluation instruments, respecting the following order: sociodemographic and clinical questionnaire, FMT, word list, ROCF, PRMT and TDR. The collection was individual and occurred at the Universidade Federal do Triângulo Mineiro.

It was defined that G1 should use Memorex daily for three months after its pre-test, without limiting the time played per day. The three-month period was determined based on the average time of interventions with games in which the exposure times varied from two to six months[14]. The research team called G1 weekly to remind them to play and check for possible problems with Memorex (crash, lack of understanding of tasks, for example). The G2 was assessed in the pre-test, received weekly follow-up calls, but were not instructed to play any electronic games.

After the intervention period, all the elderly were reevaluated, using the same battery as the pre-test. The reassessment took place between April and June of 2019.

Descriptive analyzes of each group were conducted. Wilcoxon analysis was performed for paired samples to verify the effectiveness of the intervention (G1) and possible changes derived from other causes (for G2). In addition, G1 was compared to G2 separately in the pre and post-

tests, using the Mann-Whitney test for independent samples. All analyzes considered a significance of 5% and were conducted using the SPSS program, version [23].

The project was approved by the Research Ethics Committee (CAAE 04450818.8.0000.5154) and all participants signed the informed consent form. All elderly people received a report with their test results. After conducting the post-test, the research team made Memorex available for the G2.

RESULTS

Fifty-eight elderly people participated in the study, divided into G1, composed of 29 elderly people who trained with MEMOREX for three months; and G2, with 29 elderly people who did not receive intervention.

G1 participants had a mean age of 68.31 years (SD + 6.92), predominance of women (65.5%) and more than 8 years of study (44.8%). The elderly in G2 had a mean age of 67.33 years (SD + 6.25), female predominance (72.4%) and more than 8 years of study (56.5%). The members of both groups were initially matched for age ($\chi 2 = 10.44$; $p = 0.916$), gender ($\chi 2 = 0.32$; $p = 0.570$) and education ($\chi 2 = 3.44$; $p = 0.329$), being considered equivalent. This measure aimed to control the effect of these variables on the subsequent comparison of the groups.

Figure 1 summarizes Memorex's initial screens and their tasks. Table 1 presents the description of the tasks and the evaluation of the judges.

Figure 1. Compilation of Memorex task screens. Uberaba, 2019.

Table 1. Memorex tasks and judges' evaluation. Uberaba, 2018/2019.

Task	Brief description	Game mode	Cognitive function	Judges assessment
Find the colors	Memorization of the location of colors in a matrix of images of progressive size (9 to 30 items). Between 2 and 4 stimuli can appear for identification at each level	Classic or Multitask	Visual perception, attention, memory	Adequate task; High confidence
Memory game	Search and identification of identical pairs of images in a progressive size matrix (8 to 32 items). Fruits were adopted as stimuli and the names of each fruit were included below each image	Classic or Multitask	Visual perception, attention, memory	Adequate task; High confidence
Disco	Memorization of colors and sounds presented. The sequences are progressive from 3 to 9 items	Classic or Multitask	Visual perception, auditory perception, ordering, planning, memory	Adequate task; High confidence
Identify image	An image is shown complete and then an item is deleted. The level of difficulty is related to the complexity of the image	Alternative or Multitask	Visual perception, attention, memory	Adequate task; High confidence
Cups	A stimulus is hidden under a glass and shuffled together with two other glasses. The task is to locate the stimulus following the movement of the glasses. The difficulty (7 levels) increases with the greater movement of the glasses	Alternative or Multitask	Visual perception, attention, ordering, memory	Adequate task; High confidence
Words	A list of words is shown and then deleted. Then a larger list is presented for the player to mark the words initially shown. The difficulty (7 levels) refers to the number of stimulus words and confusing words	Alternative or Multitask	Verbal understanding, memory	Adequate task; High confidence
Balloons and fruits	A sequence of colored balloons or fruits are moved around the screen, followed by questions about the colors or number of items shown (7 difficulty levels)	Alternative or Multitask	Visual perception, attention, arithmetic, memory	Adequate task; High confidence

Memorex initially presents the sources of support for its development (Universidade Federal do Triângulo Mineiro and FAPEMIG) and the program version. On the next screen, the player includes their name and can characterize their avatar in terms of age (child/adult), gender (female/male), race/color (white/black), eye color, hair type and accessories (glasses , handbag).

After characterizing the avatar, the player must choose the gameplay mode from three possible options: 1) Classic, which will present the player with tasks based on color location, images or sequence reproduction (find the colors, memory game and disco), at a progressive level of difficulty; 2) Alternative, in which the tasks are more based on visual perception, attention, ability to follow objects, verbal comprehension, arithmetic and memory (identify images, cups, words, balloons and fruits), at a progressive level of difficulty; 3) Multitask, in which the program chooses the tasks, directing the player to any of the seven tasks, at a random level of difficulty.

The judges considered the tasks as appropriate and the suggestions for change involved the inclusion of sounds to mark hits and errors and adjustments to instructions. The judges also evaluated the report, which provides the player's name, date of use, gameplay mode, total game time, total tasks played, total levels played, time for each level and task, restarts, attemps and errors. In the opinion of experts, the report needs to be simplified to facilitate its use and this suggestion will be implemented in the future.

The elderly found Memorex friendly and pleasant to use. There were no crashes or difficulties in use during the intervention time, as long as the installation was done using the option “run as administrator” when the installation is done on the computer. There were no reports of problems when the game was installed on the phone.

The analysis of the reports showed that the G1 members played, on average, 39 days (SD = 27.88; minimum of 5 and maximum of 107). The program was accessed 222 times on average (SD = 209.06; minimum of 38 and maximum of 690) and most of the time the game was used in mobile phones (72.5%). As for the way of playing, the multitasking mode was used 65.4% of the time, the classic mode 20.10% and the alternative mode 14.50%. The average number of tasks played was 3 (SD = 3.59; minimum of 1 and maximum of 7) and the average of phases was 12.59 (SD = 9.58; minimum of 1 and maximum of 44). Memorex activated the facilitation mechanism only for the memory game and the task "find the colors", which were also the most played tasks.

To assess the effectiveness of Memorex, intra-group comparisons were conducted with the elderly in G1 in the pre and post-test (Table 2). It was observed that the elderly who received the intervention showed better performance in the post-test in the TDR copy task ($z = -2.41$; $p = 0.016$), ROCF copy task, both in the score ($z = -2, 88$; $p = 0.004$) and time ($z = -2.10$; $p = 0.035$), ROCF evocation task, for scoring ($z = - 1.99$; $p = 0.046$) and evocation time ($z = -3, 39$; $p = 0.001$), FMT ($z = -2.14$; $p = 0.032$), list of words in immediate recall ($z = -2.68$; $p = 0.007$) and memory complaint ($\chi 2 = 4.74$; $p = 0.030$). The results of intra-group comparison for G2 showed maintenance of results, except for FMT ($z = -1.37$; $p = 0.034$) and the task of evoking TDR ($z = -1.05$; $p = 0.047$), in that a worse result was observed in the post-test.

The comparative analyzes of G1 and G2 showed that the groups were equivalent in terms of results of the cognitive tests in the pre-test (Table 3). However, when analyzing the results of the post-test, it was observed that G1 showed superior performance in the task of copying the ROCF ($U = 148.00$; $p = 0.002$) and in the FMT test ($U = 96.00$; $p < 0.001$).

Table 2. Cognitive assessment of groups in the pre-test and post-test. Uberaba, 2018/2019.

	G1				G2			
	Pre-test		Post-test		Pre-test		Post-test	
Variables	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
ROCF – Copy(points)	16.40	13.09	26.38*	9.32	29.20	5.37	29.36	4.94
ROCF – Copy (time)	3.75	2.71	5.47*	3.09	5.07	2.91	5.25	3.62

ROCF – Evocation (points)	8.75	7.08	20.50*	11.05	11.04	6.34	10.53	5.56
ROCF – Evocation (time)	2.33	1.63	8.45*	2.51	3.36	2.38	3.26	2.29
FMT	2.47	4.01	9.00*	4.10	3.75	3.57	1.24*	0.74
PRMT	9.28	3.71	15.00	9.71	9.52	3.40	10.10	3.84
CDT - Evocation	2.37	1.32	4.00*	2.38	2.62	1.35	1.40*	2.50
CDT - Copy	2.14	1.07	4.00	1.57	1.79	0.43	2.12	1.23
Word list (immediate recall)	18.24	4.38	20.71*	4.48	18.24	4.38	19.44	3.95
Word list (late recall)	6.14	1.79	6.95	1.66	6.51	1.92	6.86	2.08
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Memory complaints								
No	21	72.40	24*	76.20	19	65.50	20	69.00
Yes	08	27.60	05	23.80	10	34.50	09	31.00

ROCF = Rey–Osterrieth Complex Figure Test; **FMT** = Face Memory Test; **PRMT** = Pictorial Recognition Memory Test; **CDT** = Clock Drawing Test; * =intragroup difference between pre and post-test

Table 3. Comparison between G1 and G2 in the pre and post-test. Uberaba, 2018/2019.

	Pre-test			**Post-test**		
	G1	**G2**		**G1**	**G2**	
Variables	**Midpoint**	**Midpoint**	**U**	**Midpoint**	**Midpoint**	**U**
ROCF – Copy(points)	27.09	30.02	350.50	30.90	28.05	148.00*
ROCF – Copy (time)	30.52	26.33	333.00	28.86	20.86	207.00
ROCF – Evocation (points)	24.69	31.69	281.00	25.48	24.64	284.00
ROCF – Evocation (time)	23.82	31.46	261.00	22.07	27.98	232.50
FMT	28.87	28.16	381.50	26.22	22.62	96.00**
PRMT	28.25	29.72	381.50	25.81	25.28	300.50
CDT - Evocation	27.74	31.26	369.50	23.95	26.62	272.00
CDT - Copy	31.38	26.71	339.50	28.24	21.71	225.00
Word list (immediate recall)	29.50	29.50	420.50	23.93	26.64	271.50
Word list (late recall)	31.71	27.29	356.50	25.45	25.43	303.50
Memory complaints	28.50	30.50	391.50	24.45	26.26	282.50

ROCF = Rey–Osterrieth Complex Figure Test; **FMT** = Face Memory Test; **PRMT** = Pictorial Recognition Memory Test; **CDT** = Clock Drawing Test; * $p \leq 0,05$; ** $p < 0,001$

DISCUSSION

The creation and use of games on cognitive training as a form of intervention and evaluation is an area of research that is still recent in Brazil, with few national studies[19] and a gap identified in the task evaluation processes, which are not always validated[9,19]. This gap becomes greater when the intervention is mediated by computer and when the population of interest is the elderly[13,15].

Another study[23], on the use of technologies by the elderly and their relationship with self-perceived health, for the definition of game platforms, showed that the elderly indicated knowing 37 in a list of 40 technology items created up to 60 years before the collection of data and indicated that they like to use smartphones, as well as that they could use microcomputers, even if they did it in a lesser proportion.

According to previous work[28], women participate more in social activities and seek more health care than men, which may represent a bias in studies that disregard individual characteristics such as the participant's gender.

In the judges' assessment, the tasks were adequate to train the cognitive functions for which they were developed. This result can be considered as initial evidence of the content validity of Memorex. The elderly in G1 reported that they found the game interesting and pleasurable, which can be understood as evidence that the tasks are familiar and ludic, which has been pointed out as an item that interferes with the player's performance[10] and the greater use of Memorex by mobile

phone can be a useful indicator for new training programs to be developed that target this population.

The choices made for the game to have a customizable avatar and the inclusion of a reward system were based on the indication of previous studies[8] and proved to be adequate, as they were well received by the elderly. These measures, added to the facilitation system in case of consecutive errors, can help explain the good acceptance of Memorex by the elderly and help them to maintain their engagement and attention in the tasks[23].

Training impact was verified within three months. According to a meta-analysis[14], shorter interventions may have better effects when training cognitive aspects than longer ones because long-term training, since, the longer time can generate loss of motivation by the elderly. At first, it can be very exciting to play, however, over time, the elderly become tired and bored and as the cognitive gains can be subtle, the elderly lose interest and stop practicing, which impacts the results of the training with this population.

Comparisons between the elderly showed that G1 and G2 were equivalent in their personal characteristics and in the performance in the pre-test. After the intervention, the elderly who composed the G1 showed better performance than the G2 in a test that evaluates non-verbal memory (FMT) and in the ROCF copy task, which assesses visual perception, attention, problem solving and planning[5]. These results indicate that training with Memorex was efficient as a cognitive intervention for these skills. The improvement in visual perception can contribute for the elderly to involve environmental cues in a more integrated way when solving everyday problems, integrating more senses in the thinking process[4]. Attention was not evaluated, but visual perception, attention and concentration, which are related constructs, which indicates that Memorex may have the potential to assist in the development of these capacities[29].

Previous research[5,21,24] listed visual perception and organization as very important skills when performing the copy task in the ROCF and this task was indicated as a good predictor for the respondent's memory performance. That is, there is a relationship between the good planning of the copy of the figure and the memorization process[24]. The relationship between visual perception and memory can be illustrated with the best result of G1 when compared to G2 in the FMT test, which is based on the recall of faces and also on results of comparisons between pre and post-test of G1. Despite the potential for memory development with Memorex, there were no positive impacts on long-term verbal memory or tasks in evoking the ROCF and TDR (tasks related to memory) when the groups were compared.

When analyzing the intra-group results of G1, the potential of Memorex as a form of cognitive intervention proved even stronger. The elderly showed better performance in the tasks of copying and evoking the ROCF, in the task of evoking the TDR, in the tests of non-verbal memory FMT and verbal memory (List of words) and in memory complaints in the post-test. These results indicate the ability of the intervention to train aspects of visual perception, attention, planning and memory in the elderly. To perform the ROCF and TDR, it is necessary to use the motor planning and sequencing capabilities, as well as selective attention and self-monitoring of the action itself[30], so the better performance in these tasks is an indication of improvement in such skills.

When verifying the evolution between the post-test and the pre-test of the elderly in G1, there was also an improvement in memory, both verbal (immediate verbal memory) and non-verbal (face recognition). Memory is one of the processes that directly interferes with our daily activities, and represents the main complaint among the elderly. Memory can be divided, in general, into three types: short-term, long-term and working memory[5].

In short-term memory, information is stored for a short period. In long-term memory, information is retained for months, years or even decades. This is due to the fact that information is constantly reinforced over time. It can be subdivided into episodic memory, which refers to

remarkable episodes in our life and semantic memory about facts of things that we learn and are stored for a long time. Working memory, on the other hand, has the function of not only storing, but also managing or processing information and is also known as working memory. Its duration is extremely fast and is stored only within the period of use of the information[6].

Memorex showed the ability to help reduce complaints about memory performance, representing a tool with objective and subjective gains. The reduction of complaints, as well as the improvement in the performance of daily activities, represents an important point for training and is not always observed in work with the elderly[14], which reiterates the potential of Memorex as a training alternative.

Based on these results, it is understood that Memorex has the necessary characteristics so that it can be considered useful as a cognitive intervention with the elderly. This article reported its development and the beginning of studies on this form of intervention. As an initial work, some limitations need to be highlighted. Memorex is available to any interested parties, free of charge, upon request, but will continue to improve its tasks and report.

As part of the game's future development, the report will be revised. It offers useful information, but the way in which that information was presented was considered complex by the judges and needs to be simplified. At the moment, every time a player opens the program, an Excel® spreadsheet is generated and, to analyze the results of an elderly person, it was necessary to compile several spreadsheets into a single spreadsheet. As part of future improvements, Memorex itself intends to make this compilation and provide basic analyzes on increasing or reducing the time to complete phases and evolution in overcoming difficulty levels. Analyzes of aspects of behavior when playing and the performance of the elderly should also be conducted in the future.

Another work that will be developed in the future concerns the effectiveness of Memorex as a cognitive intervention with other populations. The game also allows the characterization of a child avatar, and future studies will be conducted with children to see if Memorex is useful for improving cognitive aspects of this population.

In addition, the sample of this investigation was small, selected for convenience and had a good educational level. Future studies may expand the sample and the variability of its characteristics. Future studies will also need to investigate specific aspects about how assistive technologies used by the elderly (glasses, hearing aid) interfere with training.

In this study, the use of these technologies was controlled, recording that the elderly used it, but not the control of its use, which prevented analyzes on these aspects from being conducted. The way in which the elderly use the game and its relationship with the evolution of their cognitive skills also needs to be further investigated.

In the present work, some aspects of use, such as number of days and levels played, were presented, but no analyzes were conducted on the impact of these conditions on training. Subsequent studies may clarify such relationships, indicating important aspects about the development of cognitive functions and the points to prioritize in games with a training function, showing ways in which interventions are increasingly efficient..

CONCLUSION

Memorex proved to be a cognitive intervention with playful potential useful for training the elderly, with playful potential, and that can be used in technologies available in the daily lives of these elderly people, therefore, it respects an ecological aspect of their lives, despite being electronic. In addition, its use will not imply additional costs for the elderly or researchers, since its availability is free.

The game initially demonstrated its ability to train cognitive functions, evidencing its validity and making it another tool available to professionals who work with the elderly, thus helping in the search for the quality of life and independence of this population.

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CONTRIBUTIONS
Sabrina Martins Barroso was responsible for the design and conduct of the project, data collection and analysis, writing and review. **Maria Gabriela Longo** and **Larissa da Costa Formaji** participated in data collection, writing and review. **Ana Laura Domingues de Sousa** and **Larissa Lacerda Diniz** contributed to the development of technological activities of the software and revision.

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