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Cognitive Stimulation Program Presented Through New Technologies in a Group of People with Moderate Cognitive Impairment

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Abstract.
Background: Cognitive stimulation is one of the non-pharmacological therapies recommended for intervention in dementia, consisting of activities involving different cognitive domains and involving brain activation. New technologies can be very useful in this field, favoring intervention tasks.
Objective: The objective of this work is to test the effectiveness of a cognitive stimulation intervention mediated with new technologies on a group of people with moderate dementia.
Methods: This is a quantitative, quasi-experimental study with a control and treatment group, with three measurement times (pre, post, and follow-up months after the end of the intervention). Ninety-eight subjects with moderate dementia were randomly assigned to the treatment group (N = 50) and the control group (N = 48). The treatment group received 16 intervention sessions including attention, executive function, and memory tasks, which were presented using new technologies and the activity was conducted in a group setting. Control group remained on a waiting list. The evaluators did not know which group each subject belonged to. All participants were assessed with a battery of neuropsychological tests.
Results: The results show an improvement in post-intervention outcomes in the treatment group compared to the control group on cognitive variables. No differences were found in mood depression. These results fade overtime after a few months without intervention.
Conclusion: This type of intervention is useful to maintain cognitive functioning using new technologies and in a group setting, which favors the intervention. The improvements of the intervention disappear at follow-up, which would indicate the need to maintain the intervention over time.

Keywords: Cognitive function, dementia, intervention, new technologies

INTRODUCTION

There is a belief that older adults are incompatible with new technologies; however, recent studies indicate that the older population can use them and benefit from their use [1–3]. For example, Internet use among older people has been increasing. It is estimated that 39% of those over 50 in Europe already use the internet, and although with age the use of technology decreases with help, it is still useful [4], in particular to solve aspects of their daily life and with health-related aspects [5]. This fact is associated with the emergence of a wide variety of interventions and tools through new technologies that are oriented to serve

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older people, for example, those new technologies that facilitate the autonomy of older adults in their own home through telecare or even the monitoring of movements to prevent falls through home automation [6, 7]. Numerous technological resources aimed at promoting active aging by facilitating cognitive training, encouraging physical activity, and promoting a balanced diet are also found in the literature [8, 9]. There are, therefore, many interventions based on new technologies that focus on improving people's quality of life.

With older adults, a problem of particular concern is cognitive impairment and dementias. They represent the greatest reason for dependence in older people with a prevalence of approximately 9% of the population over 65 years of age that will escalate to 11% in the coming decades [10], with much higher figures and exponential growth in those over 75 years of age. New technologies can play an important role in this field, by facilitating intervention and being able to reach a greater number of recipients with fewer resources. One of the aspects that can be worked through new technologies in people with dementia is the cognitive aspect, trying to mitigate the effects of cognitive impairment. In fact, with the advancement of new technologies, a multitude of cognitive stimulation interventions have been developed through technological supports [11–13]. New technologies can help reduce some symptoms associated with dementia, both emotional and cognitive aspects in people with cognitive impairment [14].

In addition, the implementation of new technologies in this field brings many interesting advantages. Firstly, the flexibility of new technologies allows different cognitive aspects to be used practically simultaneously. Secondly, it provides the capacity to adapt to the cognitive level of different users, being able to work on the same exercise with different users. Thirdly, they provide the capacity for continuous graduation, allowing the subject to increase his/her effort according to his/her achievements as the difficulty of the task increases, without becoming frustrating. Finally, they provide the possibility of providing immediate feedback to the user and the clinician on task performance [15, 16]. In short, the inclusion of new technologies in dementia intervention provides effectiveness by minimizing the resources that the clinician must deploy to serve a greater number of users [17].

An intervention in cognitive stimulation using a computer for 20 sessions of 30 minutes a day with people with Alzheimer's disease [18] showed an increase in cognition scores in the treatment group. A program using a computer to perform cognitive stimulation and a virtual platform for the promotion of healthy living and cognitive activation [19] with people with moderate cognitive impairment found cognitive improvements that were maintained up to one year after the end of the intervention. Recently, the Research Center and Memory Clinic of the ACE-Foundation had to adapt its care activities to a videoconferencing format using a computer screen or cell phone due to the pandemic caused by COVID-19, with positive results [19]. Also, it is important to take into account social aspects since they can favor adherence to this type of technology-mediated resources [20], hence the importance of group interventions. In addition, most centers for people with dementia carry out group activities as they consume fewer technical resources.

Despite the advantages of new technologies, some aspects must be considered that may hinder the application of new technologies for older people with dementia. The usability of the tools (ability of the subjects to be able to use certain technology), their accessibility (ability of the subjects to obtain such technology) [11, 21], and the cognitive overload they may entail must be taken into account.

Nevertheless, recent reviews [22, 23] conclude that cognitive stimulation interventions for people with moderate cognitive impairment based on new technologies are useful for slowing the progression of cognitive impairment. However, the wide variety of methods, contexts, and forms of application requires further research.

Considering the advantages of the use of new technologies for dementia intervention, as well as the importance of the social context to obtain a greater interest in the intervention and thus enhance its effects, the objective of this work is to test the effects of the application of a group cognitive stimulation program using new technologies.

MATERIALS AND METHODS

Participants

One hundred and six people with moderate dementia were recruited from care centers for people with dementia. They were then randomly assigned by a computer program to a treatment group (cognitive stimulation program twice a week for eight weeks) or a control group (an intervention that they usually carry out). Eight participants dropped out, three did

not run the program and consequently withdrew, three left their center, one died, and one declined to participate. Finally, the treatment group was composed of 50 people (mean age = 78; *SD* = 7.6) of which 35 were women. The control group finally consisted of 48 people (mean age = 80.1; *SD* = 7.6), 29 were women.

Inclusion criteria were to have a diagnosis of dementia, be over 60 years old, have a Global Deterioration Scale (GDS) score between 3–4, have been in the center for more than two months, and sign the informed consent form. Subjects with illiteracy, communication problems, or severe emotional problems were excluded.

All participants were assessed at three moments, at baseline (PRE), after two months (POST), and after three months of POST (follow-up).

Instruments

A battery of neuropsychological tests was used to assess general cognition, attention, executive function, and memory.

General cognition was assessed using the GDS [24] and Mini-Mental State Examination (MMSE) [25]. GDS is widely used in older adults with dementia to assess the general state of deterioration and establishes seven levels of impairment based on an easily identifiable clinic by the evaluator, this instrument has shown good psychometric qualities [26]. MMSE provides a total score between 0 and 30, obtained through the direct sum of the scores provided by the successes in the test, this instrument has shown good internal reliability with a Cronbach's Alpha of 0.807 [27].

Attention was assessed used with digits forward of the Wechsler Intelligence Scale for Adults-III (WAIS-III) [28]. The digits forward task involved the participant must repeat the sequence of numbers in the same order in which were read and assesses immediate recall. The average internal consistency reliability indices of its scales are usually around 0.90 [29].

In executive functions, we used the Barcelona test (BT) [30]. It is an instrument widely used in Spain and Latin American countries for general neuropsychological assessment. It consists of 41 subtests that generate 55 variables which encompass a basic spectrum of the neuropsychological functions. Two subscales were used in this study, similarities and semantic fluency (animals). All subtests had satisfactory internal consistency, with α values between 0.70 (delayed word recognition), 0.93 (for all subtests, recognition) and 0.93 (for all language subtests) [31].

Memory was assessed with the Spain-Complutense Verbal Learning Test (TAVEC). The TAVEC (full test) has an estimated reliability of 0.81 [32], which consists of a list of 16 words that are presented to the subject five times to evaluate different memory processes, such as immediate recall, learning curve, and recall after 20 minutes (long-delay recall).

Center for Epidemiologic Studies Depression Scale (CES-D) [33] was used to assess depressive mood, and it is based on how they felt during the weeklong period when they felt the worst, reliability has been estimated at a Cronbach's alpha of 0.86 [34]. It is only used for screening, to exclude people with severe emotional problems.

Procedure

Initially, we contacted by email centers for people with dementia in the province of Valencia (Spain). After acceptance to participate in the project, all information about the intervention was provided to relatives of people who met the criteria, and informed consent was obtained. The evaluation protocol was prepared, and collaborators were trained to unify the criteria for evaluation and correction of the selected instruments. The group to which the evaluated persons belonged was masked. A manual was prepared for the unified application of the intervention program. A pilot test was carried out in a small group to make corrections and improve the intervention (their data were not included).

The intervention consisted of two weekly sessions of 50 minutes for eight weeks, with a total of 16 sessions (see Table 1); employing a computer program the therapist presented the different exercises that were projected on a large screen. The therapist presented the different exercises and explained the participants' doubts. The subjects who participated in the intervention were positioned in front of the screen in a semi-circular position, ensuring full view of the information on the screen. In each session, attention, executive functions, and memory tasks were worked on. The specific activities carried out were categorization, response to previously presented short story questions, stimulus selection, social problem solving, recall of biographical moments, planning of simple tasks, and schedule analysis. The intervention was carried out in groups of eight people guided by a professional who managed that each person answered his or her tasks and that all participants participated for a similar amount of time, and each participant took turns answering the exercises orally. All sessions had

Table 1
Sessions and objectives intervention

Sessions	Objectives
Odd sessions: 1, 3, 5, 7, 7, 9, 11, 13, and 15.	– Activate and exercise semantic memory. – Stimulate and work on episodic memory. – Stimulate and exercise the cognitive function of abstraction. – Stimulate and exercise the cognitive function of planning.
Even sessions: 2, 4, 6, 8, 8, 10, 12, 14, and 16.	– Stimulate and exercise biographical memory. – Stimulate and exercise working memory. – Activate and exercise the cognitive functions of problem solving. – Stimulate and work on selective attention.

Table 2
Effects of interaction and group mean for cognitive functions

	Principal effects			Treatment Group			Control Group		
	F(2, 192)	*P*	η^2	T1	T2	T3	T1	T2	T3
GDS	3.33	0.038	0.034	3.7	3.6	3.7	3.7	3.9	3.9
MMSE	12.8	< 0.01	0.118	23.2	23.5	22.3	23.7	21.9	20.6
Digits forward task	10.23	< 0.01	0.096	4.8	5.0	4.5	5.0	4.3	4.0
BT semantic fluency	15.2	< 0.01	0.137	8.7	10.3	9.2	9.6	7.9	8.1
BT similarities	10.02	< 0.01	0.095	4.7	5.6	4.6	5.0	4.2	3.9
TAVEC immediate	4.90	< 0.05	0.049	2.6	3.2	2.6	2.9	2.7	2.5
TAVEC delayed	9.73	< 0.01	0.092	2.1	3.1	2.8	2.1	1.7	1.4

$p < 0.05$, $p < 0.01$.

the same structure: at the beginning of the session the instructions were explained, then the exercises were presented, and at the end, there was a farewell. The important thing was not the result, but the process of cognitive activation. Routines were respected to facilitate the intervention: always at the same time, the same day of the week, and the same place of work. The control group, on the waiting list to participate in the intervention, came to the centers to carry out different group entertainment activities (drawing, board games, etc.).

The program was developed by the authors who selected different activities for the cognitive areas they wanted to work on.

Statistical analyses

SPSS version 25 software was used for the statistical analyses. After checking the parametric premises, 2×2 ANOVAs were used to study the differences between groups and between times. Results with a $p < 0.05$ were considered statistically significant.

RESULTS

The main effects were significant for general cognition tests (GDS and MMSE), attention (digits forward task), executive functions (BT semantic fluency and similarities), and memory (TAVEC immediate and delayed) (see Table 2).

The study of simple effects confirmed that there were no between-group differences in any of the scores at pre-intervention; in post-intervention, significant differences between groups were observed on GDS, digits forward task, BT semantic fluency, BT similarities, and memory delayed; in the follow-up, GDS and memory delayed showed significant differences between the groups (see Table 3).

Finally, the evolution of the groups over time was studied with *post-hoc* analysis. GDS analysis showed that treatment group kept their scores stable from pre-intervention to follow-up and non-significant differences were obtained; control group decreased their scores significantly from pre-intervention to post-intervention ($p < 0.05$) and follow up ($p < 0.01$) but was maintained from post-intervention to follow-up. Regarding MMSE, treatment group differences from post-intervention to follow up ($p < 0.01$), control group differences from pre-intervention to post-intervention ($p < 0.01$) and follow-up ($p < 0.01$), and from post-intervention to follow-up ($p < 0.01$) were observed. In the digits forward task, *post-hoc* analyses showed that in treatment group there were differences from post-intervention to follow-up ($p < 0.01$), while in the control group there were differences from pre-intervention to post-intervention ($p < 0.01$), and from pre-intervention

Table 3
Simple effects between groups in pre-intervention, post-intervention, and follow-up score

	Pre-intervention			Post-intervention			Follow-up		
	$F(1, 96)$	p	η^2	$F(1, 96)$	p	η^2	$F(1, 96)$	p	η^2
GDS	0.54	0.436	0.006	7.25	**	0.070	8.28	0.005	0.079
MMSE	0.21	0.647	0.002	1.98	0.163	0.020	1.77	0.186	0.018
Digits forward task	0.73	0.390	0.008	8.50	**	0.082	3.30	0.064	0.033
BT semantic fluency	0.71	0.400	0.007	4.37	*	0.044	1.25	0.265	0.013
BT similarities	0.36	0.551	0.004	7.52	**	0.073	1.78	0.185	0.018
TAVEC immediate	0.93	0.337	0.010	1.70	0.195	0.017	0.05	0.830	0.001
TAVEC delayed	0.001	0.940	0.001	5.90	*	0.058	5.43	0.022	0.054

*$p < 0.05$; **$p < 0.01$.

to follow-up ($p < 0.01$). Regarding BT semantic fluency in treatment group, differences from pre-intervention to post-intervention ($p < 0.01$) and from post-intervention to follow-up ($p < 0.05$) were observed. While in the control group there were differences from pre-intervention to post-intervention ($p < 0.01$) and from pre-intervention to follow-up ($p < 0.01$). In the BT similarities, treatment group differences from pre-intervention to post-intervention ($p < 0.01$) and from post-intervention to follow-up ($p < 0.01$) were observed. While in the control group, differences from pre-intervention to post-intervention ($p < 0.01$) and from post-intervention to follow-up ($p < 0.01$) were observed. On the TAVEC immediate memory, treatment group differences from pre-intervention to post-intervention ($p < 0.05$) and from post-intervention to follow-up ($p < 0.01$) were observed. While in the control group, no differences over time were observed. On TAVEC delayed, treatment group showed a significant improved from pre-intervention to post-intervention ($p < 0.01$) and in the control group, a significant decrease was observed from pre-intervention to follow-up ($p < 0.05$).

DISCUSSION

Cognitive stimulation programs that make use of new technologies can be considered beneficial and obtain promising results, similar or even superior to traditional cognitive stimulation intervention in dementia [13, 35]. In this research, the effects of the application of a program based on group cognitive stimulation using new technologies were studied.

Post-treatment improvements have been found in attention and executive functions results similar to previous research [36]; however, the intervention applied in this research differs in that it is group-based. This is an important finding, as it is rare to find studies that obtain results on attention variables or executive functions with moderate cognitive impairment, and even less so when this is done in a group setting. Regarding memory, a post-treatment improvement was observed only in delayed recall, unlike the results obtained in other similar studies [37] that show benefits in immediate memory, although it should be taken into account that the subjects in our study had a greater degree of impairment. In addition, these differences could also be because in dementias immediate memory is one of the functions that deteriorate first. However, long-term memory seems to benefit the most. One possible explanation could be that, as a general rule, long-term memory, in the middle stages of dementia, is mostly preserved in dementias [38] and, therefore, with greater capacity to be worked on.

Also, a significant reduction in dependency scores was obtained. Possibly as pointed out by some authors [39] cognitive impairment is a key factor in the severity of impairment in the performance of activities of daily living, i.e., it affects the independence of the subjects. Maintaining cognitive activities helps not to increase dependence, especially when improvements in executive functions are achieved [40], similar to what was obtained in the intervention program that was applied. This is also an important finding because even if the person's cognitive impairment is at a moderate stage, working on executive functions will help to maintain autonomy, a key factor in these diseases.

Finally, it is important to mention that the effects of the intervention disappear over time in most variables, which is not surprising, since being a degenerative disease it is logical that participants worsen again; therefore, it would be important to maintain the intervention during the degenerative process to enhance its beneficial effects [41]. In this case, one session a week, on a given day, could be held. It would help the centers to organize themselves without too much cost and would facilitate the work of the clinicians.

In summary, the results are consistent with previous findings, and reinforce the idea that making use of new technologies to carry out a cognitive stimulation intervention in people with moderate cognitive impairment is beneficial, even if done in a group. The beneficial effect is found at least while the intervention is being applied.

Limitations

The main limitations of this study are the time of application of the intervention and not having maintained control of each participant's medication throughout the process. Thus, as a future line of research, it is proposed to establish maintenance sessions for several months, studying the effect of these sessions to check their possible efficacy. In addition, it would be convenient to take into account the medication during the whole intervention to check if there were differences depending on the pharmacological treatment. Finally, other limitations of the study were the absence of continuous grading, not allowing the subject to increase their effort according to their achievements as the difficulty of the task increases, without becoming frustrating, and the absence of double-blind assessment.

Conclusions

Relying on new technologies to promote a group intervention based on cognitive stimulation in people with moderate dementia is beneficial at the cognitive level and reduces dependence. However, these effects are not maintained in the long term, so it would be interesting to maintain this type of intervention over time.

Due to the scarcity of studies that have worked on this type of intervention mediated by new technologies in groups, it would be important to continue researching in the field, including the possibility of combining or adding other types of interventions such as reminiscences with a similar format to the intervention in this study.

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