The application of technologies in dementia diagnosis and intervention: A literature review

Estefania Brando BA[a,b]
Raquel Olmedo MA [a,b]
Carmen Solares MA[a,b,*]

[a]Center for the Development of Inclusion Technologies (CEDETi UC), Pontifical Catholic University of Chile, Santiago, Chile; [b]School of Psychology, Pontifical Catholic University of Chile, Santiago, Chile; [*]Correspondence author: csolares@uc.cl

E. Brando, R. Olmedo, C. Solares. The application of technologies in dementia diagnosis and intervention: A literature review. Gerontechnology 2017;16(1):1-11; doi:10.4017/gt.2017.16.1.001.00 The use of technology on dementia patients' behavioral treatments has been a growing area of interest in recent years. The aim of incorporating technological devices into dementia behavioral treatments and interventions is to support patients in their everyday life activities, maintain or alleviate some of the cognitive and behavioral symptoms and foster social interaction. The objective of this review is to know how technology has been incorporated into work with dementias, to explore the advantages and disadvantages found, and to generate a theoretical discussion that allows to propose future lines of work. In doing so, a total of 30 original studies and theoretical reviews or meta-analyses were analyzed to understand the role of technology in several stages of dementia diagnosis and treatment, but also to explore whether technology has been used as a tool for working with dementia caregivers and relatives.

Keywords: dementia, technology, dementia caregivers, cognitive intervention

In recent years, there has been a growing interest in incorporating technology into dementia behavioural treatments and interventions in order to support patients in their everyday life activities, improve their temporal, personal, and spatial orientation, and foster social interaction[1]. For instance, the use of assistive technology (AT) as well as information and communication technologies (ICTs) have been proposed as a relevant aid for the everyday life of dementia patients in several aspects such as behaviour, cognition, and functionality. Some types of AT have been included in the treatment of dementia patients as a support tool intended to facilitate complex activities such as cooking or hand washing[1,2].

Furthermore, technology makes it easier to provide personalized and effective interventions in terms of cost and time, which promote health and allow professionals to meet the needs of patients with progressive diseases such as dementias[3]. Technology also offers the possibility of adapting the parameters of a task according to the patients' performance, which improves their motivation by reducing frustration and boredom[4]. On the other hand, the use of technology in cognitive interventions makes it possible to treat patients remotely, which fosters work with rural populations who lack access to rehabilitation specialists.

Several software packages have been used as non-pharmacological alternatives in dementia treatment; for example, existing video games. Others have been specially created upon the basis of specialized guidelines; also, video games have been generated as reproductions of existing pen and paper interventions[5-7].

Virtual reality-based technology (VR) has been also included in dementia intervention programs. In fact, several studies highlight that VR intervention programs foster ecological validity, because they create fictional contexts based on real situations that make it possible for patients to transfer the learning acquired during the intervention to their everyday life[7-9].

Technology has also been incorporated into the process of evaluation and detection of cognitive decline through the design of digital platforms, generally for personal computers or tablets, which allow professionals to obtain an overview of a person's cognitive functioning[10,11]. The use of technology facilitates access to instruments for assessing neurocognitive disorders, because most of them do not require the participation of a specialist and provide a first snapshot of cognitive alterations, thus contributing to early detection[12].

Technology is not limited to the patient's treatment but also to caregivers' interventions[13]. Multiple studies have focused on the creation of psy-

choeducational programs for caregivers which provide them with specific knowledge about the evolution of the disease, acquaint them with coping strategies, and generate support networks or relief spaces for them[3,14]. In addition, treatments which take into account caregivers have shown to be effective in reducing emotional symptoms, such as anxiety and stress, and increasing confidence in decision-making[15].

Nevertheless, research on technology and dementias is still scarce. More combined effort and collaboration among professionals from different academic fields is needed to generate design models which are functional and which not only tackle the assessment and treatment of patients with dementia but also consider their caregivers.

The objective of this review is to know how technology has been incorporated into work with dementias, to explore the advantages and disadvantages found, and to generate a theoretical discussion that allows to propose future lines of work. In order to do this, a literature review was conducted to understand the roles of technology in dementia assessment, treatment and intervention for patients themselves and their caregivers.

It is important to highlight that other reviews and even meta-analyses have been conducted to explore the application of technology to dementia treatment[12,16,17]. However, to the best of our knowledge, this is the first literature review that studies how technology has been included in the several stages that a patient with dementia must go through: diagnosis, treatment, and work with a caregiver. A more detailed study of the use of technology in multiple levels of the work with dementia patients will provide a global understanding of the impact of technology on dementia disorders.

Methodology

The present literature review and compilation was based on the use of the following databases: PubMed, Scopus, Dialnet, Redalyc, and Google Scholar. The search was conducted between December 2015 and March 2016. Initially, a number of combinations of the following keywords in English were used: 'dementia', 'technology', 'cognitive rehabilitation', 'diagnosis', 'caregivers' and 'computer-based cognitive interventions'; or one of the following keywords in Spanish: 'nuevas tecnologías', 'demencia', and 'rehabilitación'. This first phase yielded more than 100 articles. Of these, several articles were discarded because they did not meet the language criteria (English, Spanish, or Portuguese); were irrelevant for the objective of this review; were repeated; did not focus on technology; and were published before 2005. A total of 30 papers including original studies and theoretical reviews or meta-analyses were divided into three thematic categories: (i) use of technology in the assessment, and diagnosis of neurocognitive disorders, (ii) use of technology in the rehabilitation process of neurocognitive disorders, (iii) use of technology on caregivers in charge of people with neurocognitive disorders. The final review included articles reporting original works, published in indexed journals as well as technological prototypes presented in research congresses.

Results

Based on the literature review conducted, the following is the state of the art in the field of technology use in the treatment of dementias. In order to make it easier to read and understand the findings, the articles were divided into the following thematic areas:

-Technology and the diagnosis of dementias
-Neuropsychological rehabilitation of dementia
-Use of technology on dementia caregiver interventions

Lastly, it must be pointed out that, in the present study, the terms Mild Neurocognitive Disorder and Mild Cognitive Impairment, as well as Major Neurocognitive Disorder and Dementia, are used interchangeably, because these terms have been developed according to the DSM-V[18].

Diagnosis of dementias

Research in the area of technology and dementia diagnosis has focused on the creation of digital tests that seek to evaluate cognitive functions briefly and globally. Due to the fact that intervention programs are more effective when there are cognitive functions that can still be preserved, it is indispensable to have tools or methods that permits the early detection of dementia[19].

Most of the technological cognitive assessment tools are based on existing pen and paper tests. For instance, the TDAS (Touch Panel-type Dementia Assessment Scale)[10] was created upon the basis of the ADAS-cog (Alzheimer's Disease Assessment Scale – cognitive subscale) [20], a pen and paper test that provides a valid and reliable evaluation of the cognitive alterations associated with Alzheimer's-type dementia[15,21]. The TDAS seeks to measure word recognition, instruction compliance, temporal orientation, visuospatial skills, recognition of object use, naming, planning of the writing process, money computation, and recognition of the time indicated by an analogue clock. This test can be administered in 30 minutes, less than the 45 minute one that the ADAS-cog requires. In addition, the ADAS-

cog must be administered by a qualified clinical psychologist, whereas the person in charge of the TDAS does not require to be a specialist. It has also been demonstrated its concurrent validity comparing general scores with those of the ADAS-cog[10].

The CNSVS (CNS Vital Signs)[22] is a computerized screening test, assessing working memory, verbal and visual memory, psychomotor speed, mental flexibility, set shifting and inhibition and vigilance and sustained attention. Gualtieri & Johnson[22] studied its concurrent and discriminant validity, as well as its test-retest reliability. They concluded that it can be used as a valid and reliable screening test in medical contexts.

The CAMCI (Computer Assessment of Mild Cognitive Impairment)[11] is an instrument designed for exploring cognitive disorders quickly and digitally. It is a self-administered test that requires an average of 25 minutes to be completed. Measures orientation, attention, executive function, episodic memory and implicit memory, and processing speed. It also provides information about neuropsychiatric symptoms, alcohol use, and perception of memory problems in everyday life. The tool discriminates cognitively healthy older adults from those with mild cognitive impairment. Becker et al.[23] contrasted the performance of 60 seropositive participants and controls in the CAMCI tasks and in a selection of pen and paper neuropsychological tests. The technological tool detected cognitive alterations with high levels of sensitivity and specificity, and the measurements obtained with it were shown to be stable over time.

Mindstreams (NeuroTrax Corp, NY) evaluates inhibition, problem solving, stroop effect, episodic memory, motor planning, processing speed, verbal functioning, and visuospatial reasoning. It has been proven to be effective in detecting the cognitive deterioration associated with mild neurocognitive disorders and early-stage dementia; also, the measures it provides are stable over time[24.] Mindstreams general results are not affected by the presence of depressive symptoms, except for the motor skills domain[25]. Fillit et al.[26] studied the usability of the tool and found that users (administrators and patients) perceive Mindstreams as an instrument that is easy to use and understand.

The CogState Brief Battery (CogState) is a brief computerized test which assesses reaction and processing speed, attention, working memory, learning, episodic memory, and decision-making. De Jager et al.[27]examined the sensitivity and specificity of the CogState test in the diagnosis of mild cognitive deterioration, comparing it with two pen and paper tests: the MMSE (Mini-Mental State Examination), and the HVLT (Hopkins Verbal Learning Test). They found that the CogState test reached a discrimination level equivalent to that of the HVLT and higher than that of the MMSE.

Another use of technology in the dementia diagnosis is through phone interviews. Costa Castanho et al.[28] compared the Telephone Interview for Cognitive Status (TICS) with the delayed recall task and a pencil and paper traditional neuropsychological evaluation in a sample of older individuals without known cognitive impairment. The TICS was constructed based on the MMSE. It consists of 13 items and evaluates spatial, temporal and personal orientation, working memory, attention and verbal memory and semantic memory. TICS showed a satisfactory internal consistency as well as high correlation levels with global scores in MMSE and the Montreal Cognitive Assessment (MOCA). This telephone interview could allow access to evaluation for patients living in rural areas and it was demonstrated to be as specific as two pencil and paper screening tests. However, as noted by Costa Castanho et al.[28], telephone interviews in the assessment of cognitive disorders may also have some limitations as the lack of limited control of environment conditions for evaluation (distractors as well as clues), also the incidence of hearing impairment and the lack of the examiners' presence to judge clinically the patient's performance.

Overall, the use of technology in the early diagnosis of dementia is a booming area of research. Wild et al.[12], conducted a meta-analysis of eleven computerized diagnostic instruments and concluded that the use of technology in the diagnosis of dementias makes it possible to standardize the administration process and the presentation of stimuli, thus reducing inter-rater variability in test administration. They provide exact measurements of response latency, offer an automatic and instant comparison between multiple performances of a single subject recorded at different points in time, and optimize the time required for the evaluation and reduce the need to train unspecialized staff to use the tools. These advantages warrant considering computerized diagnostic instruments as priority topics in the study of technology applied to dementias.

The use of technology in the cognitive assessment of dementias also has some limitations. Fillit et al.[26] propose the use of technology in assessment and diagnosis as an alternative to the neuropsychologist's role. Thus, patients could

be assessed with traditional and computerized screening tools and if results were conclusive, they would guide the start of the treatment. Patients would only be referred to a neuropsychologist if the clinical interpretation is unclear, as is the case of certain specific sets of cognitive symptoms. However, technology should never substitute for the professional; instead, like traditional assessment tests, it must be used to support clinical work. Even though the diagnosis of a neurocognitive disorder requires standardized data that can provide an objective picture of the patient's performance, it is also necessary to perform interpretative work, which includes the understanding of the whole set of symptoms and design of an intervention plan adapted to all levels (psychological and medical) and contexts (social and familial). However, other authors such as Becker et al.[23] suggest that the CAMCI, the computerized screening test, is a valuable tool for the initial study of cognitive alterations. It could be used to direct the decision-making process by indicating whether the impairment is significant and whether it is warranted to refer the patient to a more specific and extensive neuropsychological evaluation.

Cognitive rehabilitation

Several studies have recently been conducted on the use of new technologies for generating programs intended for neuropsychological intervention. These programs have been incorporated into rehabilitation in an experimental manner through devices that were initially intended for the entertainment of the population with no cognitive deterioration. In addition, specialized games have been developed by following guidelines created in order to improve intervention efficacy. Virtual reality-based tools have also been created. These programs are aimed at promoting cognitive and motor stimulation by means of the technological devices detailed below.

Technological versus pen and paper instruments

The literature review conducted yielded studies in which some commercial video games, such as BBA[29], were used as neuropsychological intervention programs for people with Alzheimer's-type dementia. Big Brain Academy (BBA) is currently being administered with the Nintendo Wii console connected to a projection screen and a wireless controller, which is used as a hand-held pointing device for completing the activities. Its main mission is to reactivate and stimulate mental abilities. In order to do this, it poses intellectual challenges in the form of games with several difficulty levels. The exercises are grouped into 5 stimulation areas and are always administered in the same order: a) perception (ability to perceive a figure visually, similarities and differences, and visuo-constructive skills); b) memory (visual recognition tasks and sound-related working memory); c) computation (simple arithmetic operations); d) analysis (visual perception tasks, visuo-construction, and semantic memory); and e) visual acuity (recognizing objects and estimating quantities; the subject must solve several problems as fast as he/she can). Each of these dimensions comprises three different types of games, structured into three difficulty levels each. This program was contrasted with other pen and paper instruments, such as the Programa de Psicoestimulación Integral (PPI) [Integral Psycho-Stimulation Program][30]. Results show that the cognitive symptoms of the experimental group, which took part in the intervention with the BBA software, decreased significantly more than those of the group that participated in the PPI intervention. In addition, the researchers found a significant reduction in depressive symptomatology in the group that worked with the BBA software[29]. Likewise, other studies reported positive results in terms of the emotional benefits that patients with dementia could derive from games.

In the same line, other studies have focused on contrasting the efficacy of programs specifically designed using new technology and that of classic pen and paper programs. Man et al.[31] conducted a study comparing the results obtained with two neuropsychological intervention programs in patients diagnosed with possible dementia. The difference between these programs is that one was virtual reality-based and the other was a classic memory stimulation program (not specified in the paper). The virtual reality-based program reproduced several contexts (a home, stores, etc.) and then displayed a number of images (objects related to the contexts shown) that the patients had to memorize as part of tasks of varying complexity and with different time limits. In both programs, the images shown were very similar, but the difference was that one displayed them using virtual reality and the other used traditional printed images. The results indicate that the group participating in the virtual reality intervention had better post-treatment outcomes. The authors also observed that the group that took part in the virtual reality intervention displayed a higher perception of self-efficacy in the use of their own memory and a stronger feeling of having improved with the treatment.

An initial analysis of the potential benefits of interventions involving such devices shows that some authors note that technology-mediated intervention programs instil motivation into the rehabilitation process due to the feedback pro-

vided by the tool[32-34]. Other authors point out that there is an improvement in psychological and behavioural symptoms of dementia at a cognitive and functional level due to the generalization of the results, added to the benefits achieved with traditional methods[35,36].

Comparisons among technological intervention
Other studies have focused on comparing the efficacy of different programs designed with new technology considering the characteristics of each. For example, Barnes et al.[37] conducted a study based on a comparison of two computerized cognitive training programs. One of these programs was based on activities that required more interaction between patients and the computer through the program 'Posit Science Corporation, San Francisco, California', which included a total of seven exercises, such as identifying the image that matches with a phrase or following increasingly complicated instructions. These exercises were intended to improve processing speed and auditory working memory. The other program was based on more passive tasks, such as listening to audiobooks or reading an online newspaper. Both programs were administered in the patients' homes and monitored during the whole training period. The results revealed an improvement in both groups, which was similar to the effects achieved with pharmacological treatments. The differences found between the two groups are not statistically significant, but qualitative differences were observed in the improvement of some cognitive processes such as memory, language, or visuospatial perception in the first group.

Authors such as Rozzini et al.[38] and Talassi et al.[39] not only found improvements in cognitive dimensions; in addition, the use of technology also had an impact on the psychoaffective sphere by reducing anxious and depressive symptomatology.

Some of the most renowned intervention programs are REHACOM[40], THINKable[41], and KiMentia[42,43] a Windows application aimed at supporting the cognitive stimulation of patients with dementia, provides physical and mental stimulation for older adults, especially those with moderate and severe cognitive deterioration. It includes sensors that allow patients to use the tool intuitively and to interact with the computer without cables, using gestures. This program is based on the theory suggesting that simultaneous physical and cognitive exercise is more likely to prevent cognitive deterioration than any of these exercises separately.

Very little research has been conducted on the rehabilitation and treatment for the social/emotional functions of patients with dementia. One of the game found in the present literature review was MINWii (Nintendo), whose main objective is to improve the patient's perception of his/her own image[44]. This initiative is also supported by positive socioemotional results in patients who received cognitive rehabilitation using new technologies[29,45-48].

It must be highlighted that technology-based interventions make it possible to conduct remote interventions. Some tools have been designed for diagnosis and rehabilitation in the home through storage devices, such as CDs or USB flash drives, programmed to be used on an interactive digital TV. This allows older adults to receive treatment in rural areas without having to travel to a large city[49].

Interventions using virtual reality
One of the main areas of improvement in this field involves the application of Information and Communications Technologies (ICTs) in rehabilitation services. This technology makes it possible to conduct interventions and provide remote support to mentally impaired people such as dementia patients. One of the most developed areas is Virtual Reality, which involves computer-generated environments that can generate real-time sensations and emotions.

Some of the programs being developed allow patients to interact with simulated artificial environments (a kitchen, a house, a city, maps, etc.) in order to train everyday life activities. One of the most recent ones is the Untitled Cooking Game[50], a serious game prototype based on a virtual kitchen where the patient must prepare several dishes, of variable difficulties, by selecting and using ingredients and cooking utensils. The Virtual Forgetfulness Test[49] allows individuals to interact in artificial environments based on spaces known by the patient. This program is useful for assessing new learning and generating interventions based on a safe place where the patient can rehearse a route from his/her home to a store. Its authors highlight the possibility of strengthening the transfer of the patient's learning to his/her personal context. Lastly, REH@CITY[7] is a multi-platform created with 3D game tools (Unity Technologies, San Francisco, USA) that can be accessed online. It is a set of tools geared towards cognitive and motor neurorehabilitation. It has different levels and provides training in the following domains: Visuospatial Orientation; Attention; Executive Functions. Patients can manage all the tasks with a list; alternatively, they can be asked to memorize them.

Studies on the effect of these interventions show

that they are promising for patients with mild cognitive deterioration, because they have the advantage of providing larger-scale interventions and some of them can adapt the treatment to the neuropsychological profile of each patient[51]. In addition, the incorporation of new technologies into intervention processes facilitates access to treatment for more isolated populations, such as those living in rural areas. These interventions also require fewer staff and provide immediate feedback.

Assistive technology in dementia

Assistive technology (AT) includes any type of technology whose objective is to improve the patient's personal security, both in the home and outside, as well as to foster the social participation, autonomy, and independence of people with some degree of disability[52]. Devices such as electronic alarms, remote controls, GPS trackers, smartphones, electronic calendars, or computer programs for cognitive, emotional, and/or behavioural intervention, are examples of AT used by people with dementia and their caregivers. The success of AT interventions depends on a number of factors, such as the patient's cognitive state, the characteristics of the electronic device selected, the commitment of the patient's relatives, and the professional support available[52]. In fact, Rosenberg & Nygard[53] highlight the importance of health professionals in the selection of the most suitable AT for the patient, a decision which must be based not only on the diagnosis but also on the person's preferences and habits. The interaction between these factors can lead caregivers and patients to considerate their experience with AT as either beneficial or frustrating[52].

The ATs that are most frequently used in the treatment for patients with dementia are technological tools originally designed as commercial products, not as ways to support the needs associated with the disease; however, they are eventually successful in intervention processes[54]. Bier et al.[55] studied the impact of smartphone use on a patient with semantic dementia as a tool for dealing with the limitations encountered in daily life, such as language failures and difficulties in planning tasks. These authors show the usefulness of simple applications available on any smartphone, such as 'Notepad', as tools that can make up for the patient's language difficulties. They also note that these technologies can be adapted to the needs resulting from the progression of the disease. Another example is the study by Lancioni et al.[1], in which a computer screen was used to present instructions to guide the completion of complex everyday tasks such as cooking. The results show that, after using these instructions, the patients managed to perform at least 85% of the stages needed to complete the proposed tasks. This study showed the usefulness of technology as a way to support patients' task of planning and their independence in daily activities.

Dementia caregiver interventions

Dementias have a direct impact on patients themselves in a number of dimensions which transcends their close family and social environment. This translates into an indirect impact on the people who live with and take care of the patient, and who are regarded by some authors as 'the second patient' or 'the invisible patient' [16,56]. Clinical studies and scientific research have revealed high rates of affective and emotional disorders in caregivers, which are mainly characterized by depression and stress. As Schoenmakers et al.[57] point out, few dementia intervention programs include specific strategies for managing this caregiver symptomatology, since they generally focus on the patient's needs, overlooking the interference that the disease causes in the environment.

Several studies focus on the impact of incorporating ATs and ICTs on dementia patient's treatment and its impact on their caregivers or relatives. These technological tools aid the caregivers of patients with dementia, reducing the psychological and physical deterioration that their work entails. In addition, they delay the need for institutional services or support, and therefore reduce the associated treatment costs. One such tool is CANDEROID[58], which seeks to provide caregivers with information regarding the patient's trajectory and location. CANDEROID basically involves the implementation in the patient's smartphone of a sensor system that collects and submits information about his/her location, along with a platform installed on the caregiver's smartphone capable of receiving this information. The system uses GPS to allow the caregiver to perform a real-time follow-up of the location and trajectory of the patient with dementia. This type of technology may reduce the likelihood of a patient getting lost due to the spatial disorientation which is frequent in dementias (DSM-V) and guarantees the patient's personal security outside the home.

Some of the studies that focus on the role of ATs as intervention tools for patients and caregivers base their methodological designs on reminiscence theory. This theory consists of evoking autobiographical memories in order to stimulate and improve a person's emotional state, and thus increasing patients' motivation to initiate interac-

tion. Astell et al.[59] is an example of the use of this theory to create a communication system (CIRCA). CIRCA includes a selection of music, photographs, and videos specifically chosen for each patient, which are shown on a computer and accessed by patients with dementia and their caregivers. The authors compare the intervention through CIRCA with a traditional reminiscence intervention which uses no technological resources. Their results show that the use of technology generates more commitment and adherence to the therapy in the caregivers, creates common spaces between caregivers and patients, which improves the quality of interpersonal communication, and has a major positive effect on the patient's emotional state in contrast with the traditional intervention.

On the other hand, a number of publications explore, in parallel with the implementation of AT in patients with dementia, the opinion of caregivers, as well as their satisfaction levels and their perception of the benefits derived from ATs[52,57,60-64]. In fact, in a literature review, Topo[17] describes that the psychosomatic symptoms displayed by the caregiver are alleviated when technology is implemented in interventions for patients with dementia.

However, the research and development of specific ATs for caregivers of dementia patients is more recent. As noted in a literature review by Godwin et al.[60], there is a wide variability in the intervention designs used and inconsistency in the assessment of the results of these interventions. Many of the studies on this topic have merely designed online psychoeducational programs that allow caregivers to increase their knowledge about the disease and its associated care[16,65]. Marziali & García[66] propose another type of online intervention: creating videoconference therapy groups. This modality allows caregivers to share their experiences remotely with other people in the same situation, which makes it easier for caregivers to enter the group and increase their support networks.

In short, the use of technology in the intervention of dementia patient's caregiver is still very limited. Some of the studies using AT for dementia patients also concern with caregivers' opinions, but few experimental designs have sought to develop caregiver-specific technologies.

Discussion

The use of technology in behavioural dementia treatments is an incipient field calling for further development. Several types of technology have been used over the last ten years for evaluating, diagnosing, and treating neurocognitive disorders, although the predominant devices are computers, tablets, and smartphones.

Regarding the evaluation and diagnosis of these disorders, technological tools available nowadays have been proven to be valid, reliable, and sensitive in the initial screening of neurocognitive disorders. Most of them are designed upon traditional and reliable pen and paper tasks and seek to briefly assess cognitive functioning. They have several advantages such as being easily transportable because of their tablet or computer format, they reduce the need of using physical materials such as paper, measures cognitive functions in a more ecological manner (by incorporating virtual reality), yields exact measurements by reducing intra- and inter-rater recording errors and they can be administered by non-specialized personnel. However, like traditional assessment tests, they must be used to support clinical work. There is also a need of obtaining normative samples[23].

Likewise, technology-mediated cognitive and behavioural interventions have a positive effect on patient performance. For instance, some studies[31] show that the technological adaptation of classic pen and paper programs has improved patients' intervention adherence and motivation. In addition, virtual reality intervention-based programs have been shown to be promising, because this type of technology can simulate real-life situations through electronic devices by creating a stimulating context that the patient can explore safely.

Nevertheless, future studies on cognitive rehabilitation in dementias must develop robust statistical designs that can demonstrate not only the positive effect of technology on patient cognition and functionality but also the benefits of its use in contrast with traditional, non-technological interventions[23]. Nowadays, available guidelines provide useful information intended to systematize the development of technological tools suitable for these patients; for this reason, technology use in interventions has proliferated. These guidelines have allowed developers to adapt commercial video games and software packages by improving their usability for interventions aimed at patients with dementia.

Regarding the use of technology for caregivers, it is important to stress how little research this literature review yielded about technologies developed specifically for the caregivers of dementia patients. Several of the studies found refer to the caregiver's role and design cognitive interventions for patients which also involve their caregivers, but do not focus on working with the latter. Other studies include technology as a means of facilitating access to information about the

disease or generating support networks among caregivers. However, it is necessary to have programs available that are specifically aimed at raising awareness among relatives and caregivers as well as tools that aid in the process of living patients with dementia. In addition, it must be noted that the available technologies, despite meeting the caregiver's needs, are not known by them, or are regarded as tools that require too much time and dedication even when administered remotely.

On the other hand, some limitations have also been linked with the use of technology for dementia patients[50]. Some studies reveal difficulties connected with the usability and the usage of the devices due to the cognitive alterations that characterize these patients[5]. Some of these technological tools do not come equipped with systems that recognize cognitive errors and help the patient to redirect his/her performance, nor do they include dynamic systems that make it possible to adjust the difficulty of the game to the skills retained by the patient and his/her cognitive profile. For this reason, software packages for working with these patients must provide the possibility of adapting to each patient's characteristics and must foster their generalization to real contexts[50].

Conclusion

In brief, the studies conducted so far are insufficient. The experimental trials carried out employ small samples and most of the devices used are undergoing improvements. Currently, few studies have provided statistical data about the properties of the interventions carried out and about the possibility of transferring these tools to the daily life of patients with dementia. It is necessary to highlight the small number of studies involving direct work with the caregiver. Few technological developments have focused on the caregiver's role, who becomes a passive participant in the intervention process. Likewise, it must be pointed out that very little attention has been paid to the functionality that new technologies can add to the creation of programs aimed at preventing, evaluating, and treating non-cognitive symptomatology in patients with dementia, such as the depressive symptoms present in many neurocognitive disorders. These issues constitute a challenge for future research.

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