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Review

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Assistive Technology and Cognitive-Behavioral Programs for Promoting Adaptive Skills of Persons with Alzheimer Disease: A Selective Review

Viviana Perilli[1], Fabrizio Stasolla[2,*], Stefania Maselli[1], Isabel Morelli[1]

[1]Villa Apelusion Medical Care Center, Bari, Italy.

[2]University "Giustino Fortunato" of Benevento, Italy.

Abstract

Background: Person with Alzheimer Disease may present cognitive, social, communication, physical, and orientation impairments. Furthermore, individuals with Alzheimer Disease may exhibit challenging behavior, isolation, and passivity.

Objectives: To emphasize the role of Assistive Technology-based interventions and Cognitive-Behavioral Programs to improve the independence, and the quality of life of patients with Alzheimer Disease. To assess the effects on teaching adaptive responding, and decreasing challenging behaviors.

Method: A selective literature review was carried out considering Alzheimer, Assistive Technology, Cognitive-Behavioral Programs, Adaptive Responding, Challenging Behaviors, and Quality of life as keywords. Twenty-six studies were reviewed.

Results: Empirical data demonstrated the effectiveness, and the suitability of the selected interventions, although few failures occurred. The participants involved significantly increased their adaptive responding during the intervention phases, and maintained their performance over the time.

Conclusion: Assistive Technology-based rehabilitative programs and Cognitive-Behavioral Interventions may be helpful for promoting the independence and the quality of life of individuals with Alzheimer Disease.

Corresponding author: Fabrizio Stasolla, University "Giustino Fortunato" of Benevento, Italy, Email: f.stasolla@libero.it

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Introduction

Alzheimer Disease (AD) is a irreversible neurodegenerative decline, which commonly includes a general loss of cognitive functioning, memory impairments, a deterioration of communication skills, an increased difficulty to performing daily activities, disorientation, and challenging behavior (e.g., wondering, urinary incontinence) [1-4]. Additionally, AD may have social-emotional negative outcomes such as depression, withdrawal, and passivity (i.e., physical inactivity) [5-6]. Accordingly, persons with AD may experience a growing negative impact on their quality of life [7-8]. Two basic categories of interventions have been up to date assessed for reducing the decline deterioration of AD, namely (a) pharmacological treatments, and (b) behavioral strategies [9-10]. The pharmacological approach relies commonly on three different types of interventions, that is (a) the use of anti-oxidants (e.g., Vitamin E), (b) the use of acetylcholinesterase (e.g., donepezil and rivastigmine), and (c) memantine, and the use of the N-methyl-D-aspartate receptor-antagonist [11-12]. The empirical evidences indicate that the anti-oxidants can have positive effects on the progression of the disease (i.e., slow down), but do not improve the individual's cognitive functioning [13]. The other treatments may have beneficial consequence on the cognitive functioning but do not increase the independence of the person in her daily life [14]. Behavioral interventions can embrace a variety of strategies consisting on (a) multi-sensory stimulation (e.g., snoezelen environments), (b) occupational therapy, (c) reality orientation therapy with attention and memory exercises. These strategies are considered critical to enhance the cognitive/functional of the individual and thus are designed to prevent the decline caused by the disease [15-16]. However, two crucial questions within this framework still remain unsolved, (a) teaching new adaptive skills, and (b) supporting the independence and the active role of persons with AD. To tackle the latter issues, one may envisage Assistive Technology-based rehabilitative programs (AT), and cognitive-behavioral interventions [17-18].

AT interventions consist of any piece, equipment, tool, or device, which may promote, support, increase, or improve the person's independence, and his/her active role towards the environment. AT brings the gap between the individual's behavioral repertoire, the cognitive functioning, and the environment's demands. Based upon learning principles (i.e., a causal association between behavioral responses and environmental consequences or events), a person with intellectual disabilities, communication difficulties, and/or motor impairments, may get independent access to the positive stimulation. Once adequately rewarded and/or motivated through brief periods of pleasant stimuli, an individual with AD can increase his/her adaptive responding, decrease his/her challenging behavior, improve his/her positive participation, and his/her constructive engagement should be promoted, with positive effects on his/her quality of life [19-20]. Cognitive-behavioral interventions may be useful and helpful for restoring the acquisition of the awareness concerning specific skills (e.g., daily activities). Thus, depending on person's level of functioning, one may rely on different rehabilitative programs, with different goals [21].

For instance, Fang et al. [22] designed and developed an intelligent health system to facilitate medication adherence in elderly patients with AD. The system achieved medication adherence by creating an audiovisual alert for the user with memory loss' disability to take the right doses of medication at required frequencies. The drug prescriptions were keyed in by the physician and the medication schedule was stored in the non-volatile memory of the technological system. At the same time, the liquid crystal display unit showed the drug to be taken in the right dosage. The buzzer in the electronic device provided a sound effect to get the attention of the patient. In case of non-adherence, the system automatically sent a text message to the physician via SMS using the integrated GSM modem and Subscriber Identity Module available in the system. The technological equipment could be miniaturized into a wearable device for optimal performance.

Diaz-Orueta et al. [23] clarified how some cognitive function (i.e., attention and verbal memory) may determine the interaction of cognitively impaired elderly people with technology. Twenty persons ranging between the mild and moderate level of AD were assessed by a means of neuropsychological and functional battery and were asked to follow simple commands from an avatar appearing on a TV by means of remote control, such as asking the participants to confirm their presence or to respond YES/NO to a proposal to see a TV program. The number of correct answers and command repetitions required for the user to respond were recorded. The results showed an improved performance in the TV task by the participants who were less impaired. Accordingly, neuropsychological assessment was considered an useful complementary tool for AT developers in the adaptation and the implementation to the elderly with different cognitive and functional profiles.

Imbeault et al. [24] planned an electronic organizer, which helped two participants, who were estimated between the moderate and the severe range of AD to performing a variety of daily activities by following a structured learning method. After the learning phase, both participants were able to use the electronic device efficiently and facilitate their day-to-day activities for several months, despite the steady progression of the disease. Data emphasized that persons with AD can profitably learn the use of new technologies to compensate for their everyday attention and memory problems, which opened up new rehabilitation perspectives in dementia care.

Despite the literature on the use of AT for AD is robust, only six reviews were found by using "Alzheimer, Assistive Technology, and Interventions" in Scopus as keywords [25-27, 73-75]. Fang et al. [25] carried out a scoping review to explore the conceptual of mild cognitive impairment (MCI) and identify the resulting ethical, political, and technological implications for the care of older adults with MCI. A comprehensive search was conducted to select English-language peer-reviewed articles published between 1999 and 2013. Results demonstrated that the MCI conceptual debate remained unresolved, the response to ethical issues was contentious, the policy response was limited, the technological interventions were not sufficient. The technological solution were re-discussed to effectively reposition MCI in the aging care discourse. Ciro [26] reviewed the effect of dementia on activities of daily living and consequently on the ability of age in place. Different types of evaluation and information conferred from different types of assessment were outlined. Evidence-based interventions for preventing and minimizing activities-of-daily-living were critically discussed. Van Hoof, Kort, Van Waarde, and Blom [27] provided an overview of existing design principles and design goals, and environmental interventions implemented at home, based on literature study and additional focus group sessions. A multitude of design principles, design goals, and environmental interventions to assist with activities of daily living and functions was evinced. The own home seemed to be a largely ignored territory in research and government policies, which implied that many problems concerning aging in place and environmental interventions for dementia were not sufficiently addressed.

Ienca et al. [73] presented a systematic review on the use of intelligent assistive technologies (IATs) for offering innovative solutions to mitigate the global burden of dementia and provide new tools for dementia care. Computer science, engineering, and medical database were extensively searched and reviewed. For each IAT, the technological type, application, target population, model of development, and evidence of clinical validation were examined. The findings revealed that the IAT spectrum was rapidly expanded, although structural limitations including clinical validation still remained. Bharucha et al. [74] conducted an extensive search of the computer science, engineering, and medical database to review intelligent cognitive devices, physiologic and environmental sensors, and advanced integrated sensor networks that could find practical and clinical applications in dementia care. The review demonstrated a specific focus on physical disabilities of younger persons with typically non-progressive anoxic and traumatic brain injuries, with few studies involving patients with dementia. de Joode, Van Heugten, Verhey, and Van Boxtel [75] determined and reviewed the efficacy of portable electronic aids for patients with cognitive delays. Most of the 25 reviewed studies, with 423 participants enrolled, referred to case reports or non-randomized clinical trials. The authors concluded that the efficacy of AT was not yet sufficiently investigated in randomized clinical trials, although the initial results were encouraging.

In light of the above, the current article was aimed at providing a selective review of the newest and updated (i.e., last decade) empirical evidence available on the use of AT-based programs for promoting adaptive skills, supporting positive participation, enhancing constructive engagement, and reducing challenging behaviors of elderly people with AD. Additionally, cognitive-behavioral interventions were examined. Strengths and weaknesses of the reviewed studies were emphasized. The effects of the interventions on the participants' performance and independence, their quality of life, and on the reduction of caregivers burden were considered. Whenever available, social validation assessments provided by external experts sensitive to the matter (i.e., AT-based intervention for AD) were examined. The implications of the findings were critically discussed. Some useful guidelines for future research and practice were detailed. The aforementioned goals of the current contribution constituted what the paper would add to the existing literature on this specific topic area of interest.

Method

A computerized search was performed in Scopus. Keywords as "Alzheimer, Assistive Technology, Cognitive-Behavioral Interventions, Mild Cognitive Impairments, Elderly People, Interventions, Quality of Life, Caregivers Burden, Positive Participation, Challenging Behaviors, Independence, and Constructive Engagement" were used to select the studies available in the last decade. A manual search was assessed as completion. The keywords were alternatively and systematically combined one to each other for the selection. The eligibility criteria were (a) at least a participant with AD, (b) at least an AT-based intervention, (c) at least an empirical study available, (d) peer-reviewed studies written in English-language, and (e) range year of the published articles included between 2010 and 2018. Accordingly to the eligibility criteria, five main categories were identified, namely (a) physical exercise, (b) daily activities, (c) reminiscence and communication, (d) leisure and occupation, and (e) challenging behaviors. Overall, 26 studies were retained with 356 participants involved. Irrespective of the number of the studies included in each category, three empirical contributions will be concisely detailed within each category. Synoptic tabs with the authors of the contributions, the number and the ages of the participants, the AT equipment or device used, and the outcomes will be available.

Literarure Review

Physical Exercise

A basic intervention approach developed for persons with an advanced level of AD, who had lost their ambulation capacity, were sedentary, and largely inactive, was aimed at supporting them with physical exercise virtually independent of caregivers' supervision. In fact, patients with severe AD are frequently equipped with a wheelchair, and are passive with negative consequences on their physical and emotional conditions. Providing these patients with ambulation opportunities may be difficult and not necessarily successful. Thus, ensuring that staff personnel help them physically during the ambulation process may not always be practicable and/or feasible, considering either the time cost or the physical efforts required. Equipping them with a safe walker device may assure them with a standing position, but does not necessarily imply that they would autonomously walk, and may cause negative emotional effects [28].

To tackle this issue, one might implement a rehabilitative intervention that combines the use of a walker with the use of AT focused on (a) monitoring the participants' step responses, (b) delivering brief periods of positive stimulation, and (c) providing encouragement to ambulate whenever predefined periods of passivity occurred. That is, the stimulation would motivate ambulation performance and, probably, foster positive personal engagement (e.g., verbalizations and smiles), while the encouragements would prevent the passivity. A basic form of AT devices, which may ensure the aforementioned process based on a learning process are microswitches (i.e., electronic tools capable of detecting small behavioral responses and delivering contingently brief periods of pleasant stimuli automatically through a system control unit) [29]. Four studies were included in this section with 35 participants involved (see Table 1) [30-33].

For example, Lancioni et al. [30] conducted two studies for helping six patients with moderate to severe AD to prevent their isolation and passivity. Specifically, Study I adopted an intervention to help three patients exercise an arm-raising movement. Study II adopted a program to help three participants exercise a leg-foot movement. The targeted response of Study I consisted of raising both arms/hands (i.e., moving them upwards).

Table 1. Reviewed studies for promoting physical exercise

Authors	Participants	Ages	AT equipment	Outcomes
Lancioni et al. [30]	6	65-94	Optic and tilt sensors	Six positive
Lancioni et al. [31]	9	75-91	Tilt sensor	Nine positive
Lancioni et al. [32]	10	73-93	Tilt sensor	Ten positive
Lancioni et al. [33]	10	67-95	Tilt sensor	Ten positive

The technology included a microswitch (i.e., tilt device fixed on a wristband that participants wore during the intervention), a computer with sound amplifier, and basic software. The computer presented 10 s of positive stimulation, recorded responses, and reminder (i.e., except for baselines during which it recorded the adaptive responses). A verbal reminder was provided every 15 s of non-independent responding. Beside step the adaptive responses, indices of positive participation were additionally registered. The targeted responses of Study II consisted of making pedaling rotation movement. The technology included a static bicycle's pedaling unit, a microswitch, a computer with sound amplifier, and basic software. The bicycle's pedaling unit was available in front of the participants' wheelchairs. They could place their feet on the pedals and making the pedaling movement while remaining seating in their wheelchairs. The microswitch was an optic sensor fixed on the ground under the right pedal and was activated when this pedal was closest to the floor. The computer worked as in Study I. Indices of positive participation were additionally recorded as in study I. Both studies were carried out according to a non-concurrent multiple baseline design across participants. Results showed that all the participants increased the performance of the targeted behaviors and improved their positive participation.

Lancioni et al. [31] assessed whether nine participants with advanced AD would learn in leg responses (exercise) with the support of a technology-aided program, which provided (a) preferred stimulation contingent on leg responses, and (b) verbal remainder/prompts in case of no responding. The leg-raising response consisted of lifting the left or right leg (i.e., always the same one or interchangeably). The technology included a microswitch (i.e., tilt device), a computer with sound amplifier, and basic software. The tilt monitored the leg responses, and the computer functioned as in contribution above described. Indices of positive personal involvement were additionally recorded. The study was conducted according to a non-concurrent multiple baseline design across participants. Data emphasized that all the participants significantly improved their performance and positive involvement during intervention phases.

Lancioni et al. [32] assessed the effects of an AT-based program, which combined a walker device with technological supports on the ambulation responses and indices of personal involvement of 10 participants with moderate to severe AD. The step response (i.e., targeted behavior) consisted of the participant's moving either foot forward thus advancing as required for ambulation. The technology included a microswitch, a notebook computer with earplugs and basic software. The microswitch was a tilt device, which was fixed to the participant's right foot and detected the step responses performed. The computer served as described above. Indices of positive participation were additionally recorded. A non-concurrent multiple baseline design across participants was implemented. Twenty-two staff persons were recruited as external raters in a social validation assessment. Results confirmed an increasing of the performance for all the participants. Social raters favorably scored the use of the technology.

Daily Activities

Behavioral strategies include a variety of approaches that for practical reasons could be summarized in two groups. One group concerns strategies that focus on reality orientation therapy and attention/memory exercises to support the overall cognitive/functional condition of the patient. The second groups deals with the efforts to re-acquire the capacity of autonomously managing daily activities. Supporting the patients to restore the ability to perform those activities is considered a way to prevent their decline, withdrawal, and isolation, with positive outcomes on their self-determination, social image, status, and quality of life [34]. Either verbal or visual prompts may be used for fostering the participants' performance. Eventually, the use of a robot may be viewed as helpful. Seven studies were retained in this section with 100 participants involved (see Table 2) [35-41].

For example, Cavallo, Aquilano, and Arvati [35] demonstrated the technical effectiveness and the acceptability of an innovative domiciliary smart sensor system for providing domiciliary assistance to patients with AD, which has been developed with an Ambient Assisted Living approach. The development, testing, and evaluation of the innovative technological solution were performed by a multidisciplinary team. Fourteen participants with AD were directly involved in defining the end-users' needs and requirements, identifying design principles with acceptability and usability features and assessing the technological solutions before and after the experimentation. A modular technological system was produced to help caregivers continuously monitor the health status, safety, and daily activities of patients with AD. During the intervention, the acceptability, the usability, the utility, and the efficacy of the system were rated as positive.

Perilli et al. [39] evaluated the effectiveness of video prompting as a strategy to support persons with mild to moderate AD. Two studies were conducted. Study I compared video prompting to an existing strategy relying on verbal instruction. Study II compared video prompting to a static strategy of pictorial cues. Eight participants with AD ranging between the mild and the moderate level were involved. An alternating treatments design was implemented for both studies. Ninety-six psychologists were recruited for a social validation assessment. Video prompting was effective in all participants. Similarly effective the other two strategies, and only occasional differences between the two strategies were reported. Additionally, the use of the video prompting was formally endorsed by the external social raters.

Silva, Pinho, Macedo, Souchay, and Moulin [40]

Table 2. Reviewed studies for enhancing daily activities

Authors	Participants	Age	AT equipment	Outcomes
Cavallo et al. [35]	14	82-86	Smart sensor system	Two negative
Imbeault et al. [36]	3	72-94	Electronic organizer	Three positive
Lancioni et al. [37]	11	61-86	Verbal cues	Eleven positive
Lancioni et al. [38]	3	73-79	Pictorial cues	Three positive
Perilli et al. [39]	8	72-91	Video prompting	Eight positive
Silva et al. [40]	51	70-89	Cognitive training	One negative
Wang et al. [41]	10	64-88	Robot	Ten positive

examined the effectiveness of a 3-training cognitive interventions (i.e., either restorative or compensatory) developed for mild AD on the performance of daily functioning. Affective state, perceived functionality, and quality of life (i.e., indicators) of 51 AD patients in the mild state of the Disease were recruited for three different programs: (a) memory and pencil training program, (b) wearable camera used as a passive external memory aid, and (c) a personal journal used as a control condition. The three indicators were assessed with standard instruments applied before the intervention, one week after, and at six months follow-up. The first two (experimental) groups (i.e., memory and camera) significantly reduced depressive symptoms compared to the control condition. Identical effects were evinced for perceived functional capacity. No intervention effect was found for the quality of life. The intervention effects were not maintained at follow-up.

Reminiscence and Communication

Beside attention and memory difficulties, persons with AD frequently experience communication impairments. Both expressive and receptive communication skills may be compromised, as well as their rehearsal process capacity. Additionally, those patients may fail in the daily management and use of communication devices such as a telephone, which can enable them of making phone calls or write short messages to distant partners. Computer-assisted technological systems, eventually combined with a telephone, and a global system for mobile communication modem (GSM) may be helpful for recovering the aforementioned abilities [42-43]. This section included 5 studies with 33 participants involved (see Table 3) [44-48].

Inoue et al. [44] developed a prototype of an information support robot for five persons with dementia, using field-based methodology. A communication robot system was chosen as the platform for this system. To achieve the goal of keeping the participants informed of their daily schedule and prompting them to take desired actions, interactive verbal algorithms were programmed in to the robot system. The results of the experiment confirmed that this system produced an information acquisition rate of over 90%. Additionally, a life support demonstration showed the possibility of prompting users to perform actions. Thus, the robot was helpful for supporting independent living by persons with dementia, and the effectiveness of the field-based method.

Perilli et al. [46] enabled five patients with AD to make phone calls independently through a computer-aided telephone system and adapted software. Specifically, the technology included a net-book computer, provided with specific software, a GSM, a microswitch, and lists of partners to call with related photos. The patients were divided in two groups, and exposed to an intervention according to a non-concurrent multiple baseline design across participants across groups. All patients started with baseline, in which the technology was not available, and continued with intervention, in which the technology was used. All the patients learned to use the system and made phone calls independently to a variety of partners (e.g., family members and caregivers). Thirty-five care and health professionals working with persons with dementia were asked to rate the patients' performance (i.e., social validation assessment) with the technology and with the help of a caregiver. The raters provided generally more positive scores for the technology-assisted performance.

Pino, Granata, Legouverneur, and Rigaud [48] developed a robot (i.e., graphical user interface; GUI) aimed at providing cognitive and social support, through a suite of applications (i.e., task reminder, navigation support, and communication). The GUI delivered these services for eleven elderly patients with MCI. An user-center design for the GUI was adopted. First, the moderator described the purpose of the research, introduced the robot, and explained the evaluation procedure. Then participants were asked to complete a series of tasks using the main menu of the GUI and navigate though its different applications. Performance and satisfaction measures were collected (i.e., time to complete each task, number of errors due to manipulation, and number of help requests). Test were carried out individually. Findings confirmed that most of the features of the GUI were adapted to the needs and capacities of older adults with cognitive impairments. However, individual factors (e.g., age, education level,

Table 3. Reviewed studies for reminiscence and communication

Authors	Participants	Ages	AT equipment	Outcomes
Inoue et al. [44]	5	71-85	Robot	Five positive
Lancioni et al. [45]	8	77-89	Computer + Microswitch	Eight positive
Perilli et al. [46]	5	73-89	Computer + GSM	Five positive
Perilli et al. [47]	4	73-83	Computer + Telephone	Four positive
Pino et al. [48]	11	70-86	Robot	Two negative

and computer experience) were found to affect task performances. Finally, some specific characteristics of the interfaces (i.e., icons and navigation system) had to be modified to make the application usable by the largest number of patients suffering from cognitive deficits.

Leisure, Occupation, and Positive Participation

Persons in the moderate level of the AD may progressively experience difficulties in the management of occupation and leisure activities due to the decline of the disease. Furthermore, independent recreation activities (e.g., listening music) may be inaccessible to them. To overcome this issue, computer-mediated technological system may represent a great practical and rehabilitative resource for reducing their isolation and increase their active role towards the outside world, with beneficial effects on their positive participation, and constructive engagement [49]. Five studies were included in this section, with 37 participants involved (see Table 4) [50-54].

Lancioni et al. [53] exposed four participants with moderate AD to a computerized-assisted technological system focused on enhancing request and choice of music options. The technology included a laptop with an amplifier, a microswitch with related interface, and basic software. The first choice situation involved four different categories of music. Each option was presented in a separate cell of the computer screen and scanned (i.e., illuminated) for 4-5 s. Prior to the scanning the system verbally asked the participants to choose what they preferred. Concomitant to the scanning each option was verbally identified by the system. The participant could select any option by selecting the microswitch (i.e., a small pressure device fixed in their hand), when such option was being scanned and identified verbally. Once the selection was made, the computer provided the participant with a new choice with four options embedded in the selected category (e.g., pop music). The participants were asked to choose one of the four proposed option available within the selected category. Once they selected the desired singer, four new options of that singer were available. They were requested to choose (i.e., by activating the microswitch) their preferred song. Typically, 2-3 min of the selected song were automatically delivered by the system. A multiple probe design across participants was implemented. Results revealed that all the participants learned profitably the use of the technology for requesting and choosing preferred music options. Forty-four psychology studente recruited as external raters for a social validation assessment positively scored the use of the technology.

Lancioni et al. [52] proposed to seven participants with severe AD a technological program aimed at comparing the effects of a self-regulated (i.e., active), and an outer-regulated (i.e., passive) music stimulation on the participants' indices of positive participation. In the active condition, the participants used a simple hand response and a pressure microswitch fixed in the participant's hand to self-regulate stimulation inputs. In the passive condition, the stimulation was automatically presented to them. A modified version of an alternating treatment

Table 4. Reviewed studies for leisure, occupation, and positive participation

Authors	Participants	Ages	AT equipment	Outcomes
Lancioni et al. [50]	8	74-90	Computer + Microswitch	Eight positive
Lancioni et al. [51]	10	78-84	Computer + Microswitch	Ten positive
Lancioni et al. [52]	7	75-90	Computer + Microswitch	Two negative
Lancioni et al. [53]	4	75-89	Computer + Microswitch	Four positive
Nijhof et al. [54]	10	72-88	Technology Leisure Game	Ten positive

experimental design was adopted. Data showed an increase in the patients' indices of positive participation (i.e., singing or music-related movements, and smiles) during both experimental conditions. The increase in the active condition was greater than in the passive condition for five of the seven participants. The other two participants evinced comparable data across conditions and a smaller increase in the active condition, respectively.

Nijhof, van Hoof, van Rijn, and van Gemert-Pijnen [54] planned a technology-supported leisure game for people with dementia in relation to the stimulation of social behavior. Its impact on behavioral outcomes of persons with dementia was explored in a nursing home and daycare setting in comparison to a traditional leisure activity. The technology was aimed at stimulate social behavior and interaction among 10 participants with AD, via its design features, including a TV, radio, telephone, and treasure box. A mixed-method research design was applied. The observations were conducted using the Oshkosh Social Behavior Coding scale. Results showed that social behavior was found to occur more often than non-social behavior. Specifically, participants with a low Mini-Mental State Evaluation Score, scored higher for non-social and non-verbal behavior. Females scored higher for social behavior than males. The interviewed activities facilitators claimed that the technology-supported leisure game helped them with their professional tasks.

Challenging Behavior

Among challenging behaviors commonly described and associated with AD, wandering is frequently observed. People with AD may show wandering in apparent confused search of something/ somebody. Other patients may show wandering without any apparent goal and display a behavioral pattern that amounts to pacing the room and the context in which they spend their time. A basic point of view among scientific community is that wandering might be an instrumental strategy to increase the patient's stimulation input in a socially-mediated or self-stimulatory way.

A second challenging behavior may be represented by urinary incontinence and toilet problems. Approaches that may be adopted to deal with the urinary incontinence problem involve the regular of diapers and other absorbent aids, timed voiding, and prompting voiding [55]. Five studies were retained in this section with 149 participants included (see Table 5) [56-60].

Barrett, Bulat, Schultz, and Luther [56] investigated baseline factors associated with caregiver-reported wandering among community-dwelling veterans with mild dementia. One hundred and forty-three veterans with mild dementia and their caregivers participated in a 2-year prospective longitudinal study. The dependent variables concerned (a) wandering, (b) daily function, (c) behavior, (d) cognition, and (e) personality. Wandering was dichotomized as present or absent across study periods, and association with baselines characteristics were examined. One-quarter of the participants demonstrated caregiver-reported wandering at 1 or more study visits with 14 to 15% wandering at anyone visit. Wandering

Table 5. Reviewed studies for challenging behaviors

Authors	Participants	Age	AT equipment	Outcomes
Barrett et al. [56]	143	71-90	Behavioral Interventions	Nine negative
Lancioni et al. [57]	1	85	Behavioral Interventions	One positive
Lancioni et al. [58]	3	80-89	Sound /Vibratory Alarms	Three positive
Radziszewski et al. [59]	1	84	Personalized Support System	One positive
Yamakawa et al. [60]	1	87	Behavioral Interventions	One positive

was associated with significantly lower baseline scores in performance of daily function, behavioral response to stress, gait, and balance, and consciousness. Wandering was associated with a specific pattern of personality (i.e., personality trait), poorer behavioral response to stress as well as greater functional,, and gait/balance impairments.

Radziszewski et al. [59] developed a personalized support system for an elderly man suffering of AD, and nighttime wandering. The intervention consisted of two phases. During the monitoring phase the system determined the profile of the person with AD, based on nighttime routines. Data were recorded through sensors dispatched in the smart home, coupled with physiological data obtained from sensors worn by the person. Data were classified to determine engine rules that provided assistance to the resident to satisfy his needs. During the second phase, smart assistance was delivered to the person via environmental cues by triggering rules based on the person's habits and the activities occurring during the night. The calm and personalized environment with music and visual icons to soothe the participant with AD and encourage him to go back to bed. Data showed a relevant decreasing of the wandering occurrences.

Yamakawa, Yoshida, Higami, Shigenobu, and Makimoto [60] matched both pharmacological and behavioral interventions for stopping wandering of an elderly woman who was aged of 62 years. Next to the pharmacological treatment, which was not reported here since it would be exceed the goal of this review, the environment was changed to meet the participant's needs. The distance moved per day significantly decreased, and the sleep disturbances disappeared. The contribution evinced the importance adequately assessing the degree of ambulation and sleep disorder. The objective indicators seemed to be critical in evaluating the suitability and the effectiveness of behavioral interventions.

Discussion

Data of the reviewed studies confirmed the effectiveness and the suitability of the AT-based interventions, and cognitive-behavioral programs for promoting adaptive skills of elderly persons with AD and different levels of functioning. The results were widely encouraging, although rare failures occurred (i.e., 4.5%). The performances of the participants significantly increased during the intervention phases. Similarly, the challenging behaviors were relevantly reduced. The indices of positive participation and/or constructive engagement improved, and external social raters favorably scored the use of the technology. Self-determination and independence of the participants were enhanced and the caregivers burden decreased. These findings were largely supported by previous contributions [61-63], and suggested the following considerations.

First, AT-based interventions may be viewed as great educational, psychological, and rehabilitative resources. In fact, they prevent isolation, withdrawal, and passivity. The AT-based programs were helpful for promoting the independence and an active role of the participants involved in the selected studies. The patients with AD were positively occupied and constructively engaged. Thus, the participants of the reviewed studies profitably learned the use of the technology. Their physical exercises were supported, their daily activities favorably managed, their communication skills promoted, their leisure and occupation opportunities significantly increased. Furthermore, their challenging behaviors were relevantly reduced. One may argue that the AT-based strategies may have beneficial effects on the participants' quality of life [64-65].

Second, the AT options may be considered as affordable solutions for caregivers and families. That is, its coast is commonly less than 1000 USD. Moreover, the AT-based solutions may be easily managed in daily contexts (e.g., home and medical or rehabilitative settings). Furthermore, the caregivers burden may be decreased because independent adaptive responding of the participants with AD was improved. Accordingly, AD patients no more relied on caregivers' assistance, with reciprocal positive outcomes. The participants restored the loosed skills and were rewarded and motivated through an individualized selection of the positive stimulation. Similarly, the technological solution were personalized for fostering their adaptation to each participant. One may argue that by designing a customer-tailored solution, the user may largely benefit of the learning process, with significant outcomes in daily contexts [66-67].

Third, because the challenging behaviors were reduced, one may argue that the patients positively redirected their efforts. That is, rather than self-stimulated, they were positively occupied and constructively engaged in new occupational tasks (e.g., picturing and/or coloring) and no more needed to be engaged in wandering. Otherwise, one may claim for an outside stimulation, which encouraged the participants and provided them with an adequate extrinsic motivation. The alarms/prompts were useful for enabling the participants with the acquisition of the awareness of an imminent urinary necessity and activated them for a specific request [68-69].

Fourth, external expert raters favorably scored the use of the technology. One may argue that their formal endorsement corroborated the social and the clinical validity of the proposed programs. Patients with different level of AD, ranging between the mild and the severe level of the disease, were exposed to profitable AT-based interventions, and were socially perceived accordingly. One may state that even if not directly involved, raters sensitive to the field and familiar to the matter (i.e., rehabilitative interventions for promoting adaptive skills of patients with AD), positively appreciated the implementation of AT-based strategies [70-71].

Fifth, the occasional failures may have different explanations. One may emphasize that the adopted technological solutions were not sufficiently calibrated for the participants who failed. At the same time, one may outline that the positive stimulation was not adequately selected and was not rewarding or motivating. Furthermore, it could be evinced that the behavioral response was not correctly retained. That is, the response coast was higher than the participant's functioning (i.e., it required an excessive effort). Finally, the learning process could not be consolidated due to an irregularity of its trend over the time. New research should be carried out for assessing the cause of the failures [72].

Limitations

Despite the encouraging and promising results of the reviewed studies, our paper presents some limitations. First, it is based on a selective review. Thus neither a meta-analysis nor a systematic review were carried out. Consequently, the findings should be considered with caution. Second, further categories (e.g., AT for spatial orientation) were not retained since their analysis would exceed the goals of the current selection. Third, the paper did not discriminate between reminiscence and communication skills, which may be useful for future research and practice. Fourth, the maintenance and the consolidation of the participants' performances were not demonstrated over the time in the retained studies.

Concluding, new research should deal with the following topics (a) new extension of the AT-based programs with new patients with AD, (b) the assessment of maintenance, generalization, and/or follow-up phases for evaluating the learning process, (c) new preference check assessment phases for the participants involved, and (d) the recruitment of new groups of external raters for further social validation procedures.

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