

SENSE-GARDEN – DESCRIPTION OF A MULTIMODAL PSYCHOSOCIAL INTERVENTION

Ileana Ciobanu¹, Rozeta Drăghici^{2*}, Andreea Georgiana Marin^{1*}, Mihai-Viorel Zamfir³, Alina Iliescu¹, Mihaela Zamfir⁴, Marius Nicolae Popescu¹, Artur J Serrano⁵, Mihai Berteanu¹

¹“Carol Davila” University of Medicine and Pharmacy, Discipline of Rehabilitation Medicine, “Elias” University Hospital, Bucharest, Romania,

²“Ana Aslan” National Institute of Gerontology and Geriatrics, Bucharest, Romania,

³“Carol Davila” University of Medicine and Pharmacy, Physiology Division, Bucharest, Romania,

⁴“Ion Mincu” University of Architecture and Urbanism, Department of Synthesis of Architectural Design, MMZ-Individual Architecture Studio, Bucharest, Romania,

⁵Norwegian University of Science and Technology-NTNU, Department of Neuromedicine and Movement Science, Trondheim, Norway

Corresponding Authors*: Rozeta Drăghici, rozetadraghici@gmail.com; Andreea Georgiana Marin, andreea.budrica@gmail.com

Abstract. We are witnessing an accelerated process of population aging and, within this process, the number of older persons living with Major Neurocognitive Disorders is also increasing. Throughout the latest research, there is strong evidence showing the effectiveness of non-pharmacological interventions in the management of cognition and mood disorders, with positive effects on behavioural and psychological symptoms. The aim of the paper is to present the content of an efficient non-pharmacological multimodal psychosocial intervention, designed for improving the quality of life of people with Major Neurocognitive Disorders and recently tested with success. The intervention includes several kinds of experiences based on emotional reminiscence, the 5 senses, cognitive stimulation and training, along with elements of physical activity. Emotions reconnect us with the world around, with the ones we love and with ourselves.

Key words: multimodal psychosocial intervention, Major Neurocognitive Disorders, reminiscence therapy, older persons

Rezumat. Suntem martorii unui proces accelerat de îmbătrânire a populației și, în acest proces, numărul persoanelor care trăiesc cu tulburări neurocognitive majore este și el în creștere. Ultimele cercetări arată dovezi serioase ale eficacității intervențiilor non-farmacologice în managementul tulburărilor cognitive și de dispoziție, cu efecte pozitive asupra simptomelor psihologice și comportamentale. Scopul acestui articol este acela de a prezenta compoziția unei intervenții non-farmacologice psihosociale multimodale, create pentru îmbunătățirea calității vieții persoanelor cu tulburări neurocognitive majore și testate recent cu succes. Intervenția include mai multe tipuri de experiențe bazate pe reminiscența emoțională, pe cele 5 simțuri, stimulare și antrenament cognitive, alături de elemente de activitate fizică. Emoțiile ne reconectează cu lumea din jur, cu cei dragi și cu noi înșine.

Cuvinte cheie. intervenție psihosocială multimodală, tulburări neurocognitive majore, terapie prin reminiscență, persoane vârstnice

INTRODUCTION

Since pharmacological treatment is the main support for the elderly living with dementia, the global cost of dementia in 2015 was estimated at 818 billion \$, representing 1,09% of the global gross domestic product [1]. However, in the long run, the effectiveness of this treatment can

be significantly increased by non-pharmacological methods such as psychological interventions, neurocognitive therapies (e.g., cognitive/emotion-oriented interventions, behaviour management techniques, music therapy, animal-assisted therapy [2] or environmental specific features. This is

especially the case in terms of the management of the Behavioural and Psychological Symptoms of Dementia (BPSD). Non-pharmacological interventions are effective alternative strategies for BPSD, increasing the quality of life levels of the older persons with neurocognitive disorders, while also facilitating the care process [3]. Caring for people living with neurocognitive disorders requires an interdisciplinary approach so that medication, psychological assistance, occupational therapy, physical activity and space design can synergistically increase the quality of life and well-being.

The latest research has brought strong evidence of the effectiveness of the non-pharmacological interventions in the management of cognition, mood disorders, with positive effects on behavioural and psychological symptoms [4]. These interventions can be divided into four categories outlined by Cammisuli [5]: holistic techniques, brief psychotherapy, cognitive methods, and alternative methods of diet and dietary supplements. These included: physical exercises and physical activities, brain exercises [6], acupuncture [7], aromatherapy [8], physical modalities [9]. Non-pharmacological interventions represent complementary techniques and should be tailored according to the patients' medical condition, resilience, compliance to treatment, Alzheimer's disease (AD) severity, available sanitary and professional resources and caregiver care commitment and support [5]. Even though there are authors emphasizing improvements in the patients' quality of life (QoL) after such interventions, studies of higher methodological quality are required to determine the efficacy of non-pharmacological interventions in people with major neurocognitive disorder. More research is also needed to determine the best practices with regards to non-pharmacological interventions [3].

With regards to space, therapeutic interventions that increase the awareness

of the older people with dementia lead to a better reconnection with the surrounding reality [10]. The environment for non-pharmacological interventions plays an important role in enhancing their effectiveness. The symptoms of dementia that are in strong connection with the environment are: spatial disorientation, locomotor disabilities, mood and perception disorders [11, 12]. These can be negatively affected by inappropriate space size, shape, colours or textures, light too bright or, conversely, too dim and by sounds that are difficult to interpret or easy misunderstand [13]. At the same time, a dementia-friendly design can alleviate some of the behavioural and psychological symptoms of dementia such as wandering, spatial and temporal disorientation [14]. The integration of the spatial aspects within the non-pharmacological therapy makes the intervention "multimodal".

A systematic review published in 2020 offers an important conclusion regarding the benefits of multimodal non-pharmacological interventions aiming to improve the cognitive functioning of people with dementia syndromes [15]. The authors identified 26 studies providing results of multimodal therapy programs including two or more different modes of intervention, applied in a personalised manner and measuring a cognitive outcome. Combined cognitive, physical, psychological and psychosocial interventions, nutrition, fasting, gut health, sleep hygiene, stress reduction, detoxification, hormonal health and oxygen therapies/treatments/interventions were reviewed. The findings report a delay of cognitive decline and even cognitive improvements for multimodal interventions. As a result, the non-pharmacological multimodal interventions are a promising approach, able to complement pharmacological methods in order to improve the cognitive functioning of people with dementia [15]. Another systematic review, this time regarding multimodal interventions for patients with

major neurocognitive disorder (MNCD) showed that a combination of physical exercise with cognitive training and activities of daily living, provided for 30 minutes, 3 times per week over at least 8 weeks is recommended for improving global functioning, as well as specific cognitive functions in the patient [16]. The authors also emphasize that cognitive training should focus on memory, executive function, visuospatial function and constructional ability.

Thus, including technology in the intervention can be an effective way to account for all these complex activities and at the same time, be efficient in helping the older adults with MNCD. Multimodal interventions based on information and communication technology (ICT) is an emerging practice in recent years for patients with neurocognitive disorders [10]. A 2020 study concludes that even if people with neurocognitive disorders use ICTs on a daily basis (smartphones and tablets), the use of apps designed to assist memory is limited. Interventions using these technologies are needed to overcome barriers in this population segment that are related to the lack of acceptance of new technologies in people with specific socio-demographic characteristics [17]. A systematic review regarding ICT for reminiscence therapy (RT), published in 2014, concludes that ICT may support RT in many ways, by offering easy access to multimedia RT triggers, new means for communication and participation, with an important reduction of the multiple barriers and limitations of classical RT interventions [18]. Efforts are made to enhance the personalisation of the RT experience offered to people with neurocognitive disorders by means of ICTs [19].

SENSE-GARDEN is such a multimodal intervention program based on an innovative ICT system providing stimuli to the different senses, such as sight, touch, hearing, balance and smell [20]. SENSE-GARDEN aims to meet the needs of the

elderly person living with major neurocognitive disorder in terms of emotional communication in a familiar, safe environment, reconnection with reality, stimulation and training of cognitive and physical functions (including proprioception and balance). “The SENSE-GARDEN spaces are self-contained physical rooms equipped with digital technology to create an immersive environment, measuring typically between 25 square meters and are installed inside care facilities.” A SENSE-GARDEN integrates digital technologies and individual meaningful media content, which is personalised to create a targeted therapy producing reminiscence effects in the patient [21].

The novelty of the SENSE-GARDEN method consists of the manner in which the intervention is composed and managed in order to create and use emotional memory anchors. These anchors are used to engage the users in the training steps. An ICT based system to offer visual, audio, touch, olfactive and proprioceptive stimuli generating a smooth experience. The intervention is based on reminiscence therapy through meaningful multiple sensory stimulation, focused on emotional reconnection with the self and others, which is used to enable and support reality orientation and improve the participation of the person with major neurocognitive disorder. The intervention combines emotional RT with personalised cognitive and physical training approaches. The 2018 Cochrane systematic review on RT impact on MNCD concludes that there is not enough high-quality methodological research to state that RT can improve QoL for patients with MNCD, but states however that RT is superior to other activities in terms of reconnection and that “RT can now be viewed alongside cognitive stimulation as an eco-psychosocial intervention with a credible evidence-base” [22]. There are many studies showing increases in QoL levels and cognitive measures immediately after

the RT intervention, especially when personalised, no matter the conditions generating the syndrome. Participation outcomes show improvements after RT interventions, too. The intensive character of the intervention program (5 sessions per week) may have influenced the outcomes in a positive manner. The benefits of involvement of the family members in the reminiscence approaches is also emphasized in the Cochrane review [22]. The effectiveness of the SENSE-GARDEN intervention, applied in an intensive manner, for 20 sessions (1 session per day, 5 sessions per week) has been shown in a recently published paper. Study's International registered report identifier is DERR1-10.2196/14096 [23]. The study published in 2022 presents the results of a series of 7 cases. Participants presented with major neurocognitive disorders of vascular and mixed origin. They participated in a SENSE-GARDEN program including personalised and adaptable experiences of Reality Wall, Move to Improve, Memory Lane, Life Road, with scents, old movie clips and music. The program was customised to enable emotional reminiscence and cognitive rehabilitation, along with elements of balance, upper limb (in the butterfly game) and lower limb coordination and aerobic exercise (cycling, in Life Road). The SENSE-GARDEN study protocol is published elsewhere [24]. All parameters assessed during this intensive study showed statistically significant changes after intervention, indicating improvements in all domains of interest: cognitive and physical functioning, activity and participation. The changes were noticed not only in terms of means, but were documented for each participant [23].

THE SENSE-GARDEN EXPERIENCE

The design of the experience

- *Architectural aspects*

The environment in which the multimodal intervention is offered to the user is

important. The space used for intervention delivery in SENSE-GARDEN has been prepared with regards to its interior design and equipment in order to meet the requirements of the delivery of the different experiences, in terms of dementia friendly principles [14] for safe and efficient sensory-motor and visuo-spatial training [25].

The space used for the SENSE-GARDEN needs to enable and support the whole intervention. Thus, an optimal space must be designed in accord with the principles of dementia-friendly architecture and must offer appropriate distances for sensory and motor training as well as for navigation between the media and interactive equipment. Space must provide access and a conducive experience, in a pre-set or ad-hoc established flow. Walls must be neutral in colour (white) and can be plane or curved (in accord with the capabilities of the media projector devices). Natural light providing information in regards of the season, weather and moment of the day should be accompanied with enough artificial light to avoid shadow but allow projected images to keep clarity and colours.

To maintain a state of well-being and therapeutic comfort, the space was designed to include natural plants and natural lighting to maintain a permanent connection with nature. At the same time, natural lighting must be helped by artificial lighting in order for this space to keep its supportive qualities of therapeutic experiences at a constant standard throughout, day and night. Moreover, the facts that natural light fights depression [26] and at the same time, that artificial light helps a good focus on different activities were accounted for. Older persons with neurocognitive disorders need a higher level of lighting [13, 26] but glare and shadows must be avoided. In this aspect, artificial lighting offers additional therapeutic comfort, because it is easier to control. The lighting of the space was, thus, an important aspect within the SENSE-

GARDEN project, enhancing the 6 experiences uniformly or differently depending on the type of training or on the time of day. The architecture was permanently in tandem with the technology, each one potentiating the other.

- **Equipment**

The equipment used to provide the means for the SENSE-GARDEN intervention program included the computer providing an innovative ICT-based technical platform ensuring the integration of the user-technology interfaces, a tablet for the remote control of the therapeutic experiences, a short-throw interactive projector, an All-in-One PC with touchscreen monitor and a four-limb stationary bicycle. The app on the tablet offers the means to create personal profiles and workflows containing personal, thematic, and culturally specific media (personal photographs and videos), as well as general media reminiscence triggers (publicly accessible images, videos, and music). It also offers the therapist the possibility to give real time feedback to the system, through a tablet interface, using emojis to express the emotional status and the emotional reaction of the primary user to the different triggers and activities included in the workflow used during a specific SENSE-GARDEN session.

The equipment is integrated by innovative ICT, to enable smooth workflows and experiences. ICTs are used lately on a positive trend for providing different interventions for PwD and their caregivers [27]. A 2016 systematic review of the literature about ICT applications that have been developed to assist patients with AD and their primary caregivers found out that ICT (information systems and internet) are used for information management as well as for healthcare (assistive technologies, telecare, telemedicine) for people with neurocognitive disorders. The review concludes that the use of ICT equipment should be recommended for the older adults' everyday life, as it has been shown

to improve their QoL as well as their caregivers [28].

The content of the experience

In the SENSE-GARDEN space, the patients were actively involved in a succession of 6 different experiences, as described in Table I. The following subsections show samples of tasks that can be given to a SENSE-GARDEN primary user divided by the SENSE-GARDEN activity category.

Initial decompression

Get the user focused on space, time and on activities to be performed during the session (salute, talk about weather, health condition today, remember previous SENSE-GARDEN sessions or explain what it is all about, gain the patient's interest for this).

- ***Reality Wall***

Create an atmosphere that engages the patient in reminiscence activities and good feelings (use nonspecific content – movies depicting nature – select the favourite leisure-time geographic spot and features, if possible), attempt to encourage the user to talk about trips of old times they enjoyed, remember space and time markers, as well as the participants and the activities involved. Some new input regarding media content which can be used for future sessions might be obtained. Slow panoramic nature or town videos and relaxing soundscapes are recommended.

- ***Memory Lane***

If beneficial, approach the personal memories regarding the patient's family, friends, crafts, profession, hobbies, etc. Use photos from personal events, related music, and allow the user to engage in remembrance activities. If beneficial, enquire about the current status of the family members, of their relationships and of their feelings. Allow the primary user to interact with the photos and help them create correlations and narrative endeavours. Adapt the content features (complexity of image, colours, content,

associated music) to the cognitive and sensory status.

- ***Life Road***

Choose driver-view video recordings with appropriate speed and image quality, preferably recorded in well-known places, to improve reminiscence and space and time orientation. As a supplementary cognitive task, the patient can be involved in samples for train-trip tasks (i.e., keep in mind the number of tunnels, viaducts, train stops; remember geographic highlights, season, flora, activities people are engaged in).

- ***Move to Improve***

Explain the game, each time if necessary. Select the degree of complexity and difficulty of the game in accord with the user's cognitive and sensory limitations. Use a simple static background (the image of a park, mountain pasture, plain field, lake shore or seaside). You may change the background from session to session, to increase curiosity and stimulate exploratory behavior. Then, adapt the tasks to the degree of focusing and engagement you notice. It is important to choose the right soundscape. If the music is too engaging, it may determine the user to dance, and it may also reduce the focus on the cognitive task at hand. Persuade the user to move as much as possible: back and forth to see the image and to act on the butterflies, and with a large range of motion to reach the butterflies from the same position, as many times as possible (i.e., engaging the patient in motor and balance tasks).

Regarding the butterfly game for cognitive, upper limb and balance training, we propose a multi-level approach:

- *level 1*: simple association game: the way it is now, with choices for number and size

of flowers, plus the possibility to choose a different background image?

- *level 2*: multiple choice association game. Disturbing elements may appear: butterflies, bees, buzzing wasps and flies, maybe a flying small panda-bear. The user's task is to choose the butterfly, place it on the right flower, then do the same with the bees, but the user has to eliminate the flying panda-bear or other non-identified flying object which is out of context and place it in a recycle bin, or in a mail box.

- *level 3* (or a *level 2bis*): short term memory association game. The user must follow a pattern to train short term memory even more. For example, a color algorithm must be followed. When a lot of differently colored butterflies appear on the screen, along with the same number of colored flowers, the user has to pair them in the order of the colors indicated at the beginning, in a short-lived image. Begin with 2 x 2 pairs and go up to 7 colors and 7 pairs of butterflies and flowers. Please, can you do this? Disturbing elements may appear, to make it more difficult.

- ***Films of My Life***

Choose engaging items, with lyrics and rhythm, such as fragments of old movies (in accord with the personal preferences, rather than the époque). Motivate the user to *engage* in singing or/and remembering the movie plot, song lyrics, characters, gags and stuff.

Final decompression

Remember the content of the session, define the feelings it generated. In a small interview regarding the session, set the space and time coordinates, support the user to take initiative regarding the next activities of the day.

Tab. I Experiences of a SENSE-GARDEN session

The experience	The device used	Media content	Targeted functions
Reality Wall	a short throw interactive projector - reality projection	★videos with nature-depicting images ★personal videos from family vacations	<ul style="list-style-type: none"> ● perception of space ● working memory ● focused attention ● language and communication
Memory Lane	all-in-one PC with touch screen monitor	★personal photos from patient's family album or, when a personal photo album was not available, specific media content in accordance with the personal preferences - music, films, movie stars, profession, books, authors, etc.	<ul style="list-style-type: none"> ● long term memory ● perception of time ● focused attention ● problem-solving ● storytelling - language and communication ● executive function
Life Road	four-limbs stationary bicycle large TV screen or short-throw projector	<ul style="list-style-type: none"> ★real-life routes or ★short movies from family history albums ★working sheets - remembering specific key trigger elements at the end of the training with the stationary bicycle following a virtual bike/train/car trip, by responding to questions 	<ol style="list-style-type: none"> 1. physical training <ul style="list-style-type: none"> ● motor control, coordination ● visual ● proprioceptive 2. cognitive training <ul style="list-style-type: none"> ● explorative attention ● space attention ● working memory training
Move to Improve	exergame - cognitive training application developed on 3 levels of complexity	<ul style="list-style-type: none"> ★ simple game (easy, moderate or advanced) ★ complexified tasks: <ul style="list-style-type: none"> ● comparisons and associations ● matching pairs ● digit span backwards 	<ol style="list-style-type: none"> 1. cognitive training <ul style="list-style-type: none"> ● short term memory training ● medium term memory training ● backward memory span ● executive function 2. physical training <ul style="list-style-type: none"> ● motor control, balance and coordination ● visual ● proprioceptive
Sounds Surround Me	surround system that can be integrated with video projection	<ul style="list-style-type: none"> ★instrumental music, favourite singers, actors, movies and soundscapes, short family videos ★smart lists 	<ul style="list-style-type: none"> ● positive affect ● memory ● communication ● engagement
Scent to Memories	intelligent scent release system	★ perfumes with emotional reminiscence effects	<ul style="list-style-type: none"> ● mood ● memory ● engagement

The SENSE-GARDEN Procedure

The therapeutic process is conducted by one clinical psychologist, designated as

“case manager”, who is responsible for choosing the workflow for each working session and for adapting the complexity

level of the tasks in order to personalise the therapeutic session. One technical manager is also present, as the one responsible for the media content and technical support through all the 6 experiences, in order to provide a smooth and appropriate experience for each participant in the SENSE-GARDEN space. One family caregiver was invited to participate, when available, at the SENSE-GARDEN sessions, in order to catalyse the reminiscence of the past experiences lived by the person with dementia and to enhance the emotional reconnection with the self and with the environment.

The visit to the SENSE-GARDEN room is a personalized intervention of reminiscence therapy and multisensory stimulation. In order to personalise the intervention, the Sensory Profile (adult version) of the participant is created and the ALMA (Art of Life Memory Album) questionnaire [29] is filled in. The Sensory Profile offers insight regarding aspects of sensory processing, sensitivity, sensation seeking or avoidance. The Sensory Profile is considered by professional caregivers for elderly as a valuable tool, offering caregivers a more complete image of the limitations and needs of the person they are caring for [30]. ALMA is a questionnaire focusing on life events, preferences and emotional aspects relating to the participant. It allows the case manager to collect relevant information to set up the SENSE-GARDEN sessions, for example regarding family events, professional activities and hobbies, favourite scents, movies and music preferences, friends, pets, favourite places and tourist destinations, amongst others. The preparation of a session is very time consuming, requiring effort to collect and process the necessary media (e.g., photos may need to be digitalized, videos have to be edited, etc.).

In order to be able to optimally deliver the SENSE-GARDEN experience, the staff is required to have:

- at least 6 months experience in working as a caregiver for people with dementia;
- at least one formal training in these aspects: working with people with dementia, gerontopsychology, reminiscence therapy for elderly, and/or multisensory stimulation for people with dementia;
- knowledge and practical experience regarding physical therapy (exercise) for older people (with and without cognitive challenges) with frailty syndrome;
- high levels of respect and empathy for elderly;
- high levels of creativity as well as clinical reasoning in designing the user profile, the activities, the workflows and the sessions.

The steps for planning a SENSE-GARDEN therapeutic session are:

1. media-content gathering;
2. creating and preparing workflows (media sequences);
3. establishing back-up media-content/ solutions to provide the SENSE-GARDEN session to the user/ patient;
4. preparing the environment, the SENSE-GARDEN room;
5. beginning/ containing and ending the SENSE-GARDEN session - ambient music and fragrance adapted to the personal preferences of the patient and also, to the personalised media-content prepared by the therapist and displayed on the selected devices by the technical manager;
6. obtaining feedback from the user/ patient.

THE SENSE-GARDEN BENEFITS

One of the special outcomes of our study is the improvement of engagement of the participants, as well as the improvement of related parameters, during and after the intervention program. Engagement in social activities is proved as beneficial in preventing or delaying cognitive impairment and assessing engagement and participation provide important insight regarding the effectiveness of an intervention [31]. Engagement is a

multifactorial, global measure and engagement level influences affect, behaviour, and image of self [32]. Social disengagement is a predictor of the risk of cognitive decline and of a lower level of QoL [33]. Mood decline is one of the most potent predictors of decrease of engagement, pushing also the decline of cognitive functioning [34].

An important, but unquantified, effect of the intervention program in SENSE-GARDEN was noticed by the family caregivers in regards to daily life behaviour: improved initiative and increased ability to finalise tasks, to start and sustain communication with family and strangers (even offering voluntary support for different tasks), a better capacity of organising things, a higher level of involvement in family life, and improved space and time orientation. This may be due to the active presence of a therapist during the intervention and to their ability to engage the participants in communication and activities, along with family members, when possible. The active involvement of a younger generation in reminiscence therapy increases the pleasure and engagement of the older person, if common interest is elicited by the items used, and the creation of a library of photos for reminiscence therapy is useful [35].

The positive results of the intervention program are possibly linked to two important factors. On the one hand, the highly personalised nature of the experience, with the use of personal sensory and emotional memory triggers based on each participant's life history. On the other hand, they could be due to the attentive, empathic, and compassionate involvement of a staff member (in the case of our study, a clinical psychologist who acted as case manager for all participants). Nonetheless, the cognitive flow of the whole experience may have benefits on its own, too. Participants were provided with concrete, well-adapted, realistic objectives and simple and intuitive rules. They were

engaged in the smooth and well conducted flow of the experience, without distractions and providing important and meaningful stimuli for senses, mind and emotion. These conferred to the SENSE-GARDEN intervention the qualities of a dynamic, personalised and serious game. Tasks' content, intensity and difficulty were adapted to elicit all cognitive functions. The interactivity and the palette of experiences was designed and managed to avoid boredom and disengagement, while optimally stimulating the active participation of the user, which is beneficial, as most previous research shows [23].

The multimodal intervention applied by means of an ICT based intervention is in line with the 2020 recommendations of the Lancet Commission [36] regarding dementia care: (i) the need for holistic post-diagnostic care addressing physical and mental health, social care, and support, and (ii) the use of specific multicomponent interventions as treatments of choice, which represent valuable alternatives to pharmacological interventions for the improvement of the behavioural symptoms. This approach is also in line with the conclusion of the systematic review conducted by Chalfont [37] on multimodal interventions for patients with major neurocognitive disorder: multimodal non-pharmacological interventions can complement singular therapeutic approaches and provide important improvements as they address multiple modifiable risk factors currently understood to influence cognitive decline. Further research is, however, required to offer insight into the mechanisms through which such a multimodal approach provides benefits.

There is a growing number of studies suggesting that physical activity and exercise have positive effects on cognitive function of the elderly [38; 39]. Indeed, greater balance and gait disturbances have been found in people with dementia when compared with older people in general [40;

41] and these have been shown to occur in relatively early stages of the dementia pathway [42]. These declines in balance and motor performance may explain the increased incidence of falls in people with dementia, and have been shown to be a predictive factor for people with dementia needing permanent skilled nursing facility admission [43]. The main reason for the relationship between cognitive function and balance function might be the structural or functional change of the brain. Recently, it was reported that hippocampal volume is associated with maintaining upright posture and balance [44; 45]. Reduced grey matter volume has been found to be related not only to cognitive decline, but also to postural instability [46]. Studies indicate that aerobic exercise and balance training are beneficial for people with dementia, reducing the risk of falling, improving their physical and psychocognitive condition, with all subsequent beneficial consequences, including improving the domains "Activities" and "Participation" of the ICF [47; 48; 49]. Importantly, a systematic review [50] showed a positive relation between exercise and improvement in overall cognitive function (operationalised as improvement in MMSE and ADAS-Cog scores). In their review, Mandolesi [51] concluded that physical exercise determines positive biological and psychological effects on the brain and on the cognitive function. Recently, Machado et al suggested that physical exercise is an important neuroprotective modulator, controlling the disease and amplifying significant brain functions. Gallaway et al [52] proposed several potential mechanisms for this, as physical activity can increase blood flow to the brain, improve sleep quality, improve cardiovascular and metabolic status, prevent and treat depression. It has been reported that the combination of aerobic exercise, balance training, cognitive training, the Mediterranean diet and social commitment could reduce the risk of

further cognitive impairment and may improve cognition, mobility, balance and QoL in people with MCI [53]. The parameters of physiotherapy interventions cannot be precisely defined, but it is recognized that aerobic exercise that is intense enough to cause an increase in heart rate and oxygen consumption will be effective if sustained for a period of time (i.e., 20-30 minutes per session and administered repeatedly) [54].

The SENSE-GARDEN technology enables the therapist to create a personal profile of the primary user by uploading processed personal media content, preferred general media content and culture-specific triggers. Based on the triggers, on the Sensory Profile, on the emotional status and reactivity and on the results of the assessment of cognitive functioning, by means of the Clinical Dementia Rating Scale and Mini-Cog assessment tools, as well by clinical interview, personal workflows are created, providing users with activities and experiences adapted to the patient's level of cognitive impairment and disability. This adaptation is regarding the image and sound complexity, task difficulty, the number and features of sensory modalities that are applied simultaneously. A specific workflow is chosen for a specific session by the therapist, by considering the mood and reality orientation of the participant before the session. During the session, workflow activities are conducted and changed by the therapist, while the tasks are adapted in terms of complexity and duration in accordance with the moment's requirements, for a better and more beneficial experience.

The space can contribute to the effectiveness of therapeutic conduct dedicated to people with neurocognitive disorders if it is designed on dementia-friendly principles [55]. In this sense, the dimensions, and proportions of the space and the way in which architectural instruments such as light, shape, colour, sound texture are used are important [13].

A therapeutic space such as the SENSE-GARDEN from Elias Hospital relies on chromatic and design neutrality to enable and to enhance the user experience [20]. Basically, the architectural instruments were combined with the technology in such a way that led to the achievement of a balanced and agreeable proportion between the physical and digital aspects.

A similar approach regarding the design of the intervention to the one in the present study was used in a study published in 2017. Cognitive training, cognitive stimulation, reality orientation, physical therapy, reminiscence therapy and music therapy were applied in what was named Multimodal Cognitive Enhancement Therapy (MCET) in older people with major and mild NCDs. The study, a cross-over (2 periods of 8 weeks separated by 4-week wash-out phase) multicentric double-blind randomised controlled trial, resulted in significant improvement in MMSE score (effect size 0.47), QoL score and behaviour. The MCET was shown to be more efficient than conventional cognitive enhancing activities [56].

In conclusion, after taking part in the SENSE-GARDEN sessions, important improvements were documented in the participants' cognitive and physical functioning, as well as in their emotional condition, behaviour and QoL. However, this is only a starting point in understanding the effectiveness of this intervention, and of the non-pharmacological treatments as a whole. The positive results noticed in the SENSE-GARDEN participants could be explained by some other factors as well, such as the caring nature of the staff or the flow of the experience (regardless of its specific activity), therefore more evidence is needed to disentangle the effects of the intervention from the effects of any covariates. Another point to consider is that there is no knowledge on whether the observed effects are lasting in the long-term or not. Therefore, in order to be able to draw more precise conclusions on the effectiveness of the intervention, more research is needed. These scientific efforts could lead to ensuring a better life for the older adults living with major neurocognitive disorders.

Conflicts of interest

The authors declare no conflicts of interest.

Acknowledgement

This work was supported by the EU AAL Programme, Project SENSE-GARDEN (AAL/Call2016/054-b/2017), with implementation period June 2017 - November 2020) co-funded by the European Commission and National Funding Authorities of Norway, Belgium, Romania, and Portugal. We would like to thank Ronny Broekx (ePoint, Belgium), Iulian and Catalina Anghelache (CanaryTech, Romania), Mara Diaconu (NTNU), to all the members of the SENSE-GARDEN team as well as to all the participants in our studies.

REFERENCES

- [1] Alzheimer's Disease International. (2015). World Alzheimer Report 2015. <https://www.alzint.org/u/WorldAlzheimerReport2015.pdf>.
- [2] Abraha et al. Systematic review of systematic reviews of non-pharmacological interventions to treat behavioural disturbances in older patients with dementia. The SENATOR-OnTop series, 2017, 7 (3):e012759 BMJ Open.
- [3] Berg-Weger M, Stewart DB. Non-Pharmacologic Interventions for Persons with Dementia. *Mo Med*. 2017, 114(2):116-119.
- [4] Marin AG, Ciobanu I, Zamfir MV et al. Work Protocol for Cognitive Optimization Intervention Using Computer Applications in Patients with Cognitive Impairment after Stroke. *International Journal of Modeling and Optimization*, 2017, 7(4): 245-250.

- [5] Cammisuli DM, Danti S, Cipriani G et al. Non-pharmacological interventions for people with Alzheimer's Disease: A critical review of the scientific literature from the last ten years. *European Geriatric Medicine*, 2016, 7 (1): 57-64.
- [6] Schultz SA, Larson J, Oh J et al. Participation in cognitively-stimulating activities is associated with brain structure and cognitive function in preclinical Alzheimer's disease. *Brain imaging and behavior*, 2015, 9(4), 729–736. <https://doi.org/10.1007/s11682-014-9329-5>.
- [7] Shi-Qi M, Hai-Peng H, Meng-Qi L et al. Effects of acupuncture on dementia: An overview of systematic reviews. *European Journal of Integrative Medicine*, 2021, 41: 101256. doi: <https://doi.org/10.1016/j.eujim.2020.101256>.
- [8] Jimbo D, Kimura Y, Taniguchi M et al. Effect of aromatherapy on patients with Alzheimer's disease. *Psychogeriatrics*, 2009, 9(4):173-9. doi: 10.1111/j.1479-8301.2009.00299.x
- [9] Saltmarche AE, Naeser MA, Ho KF et al. Significant Improvement in Cognition in Mild to Moderately Severe Dementia Cases Treated with Transcranial Plus Intranasal Photobiomodulation: Case Series Report. *Photomedicine and laser surgery*, 2017, 35(8): 432–441. <https://doi.org/10.1089/pho.2016.4227>.
- [10] Goodall G, Taraldsen K, Serrano JA. The use of technology in creating individualized, meaningful activities for people living with dementia: A systematic review. *Dementia*, 2020, 1471301220928168.
- [11] Trivedi DP, Braun A, Dickinson A et al. Managing behavioural and psychological symptoms in community dwelling older people with dementia: 1. A systematic review of the effectiveness of interventions. *Dementia (London, England)*, 2019.
- [12] Oliveira A, Radanovic M, Mello PCHD et al. Nonpharmacological interventions to reduce behavioral and psychological symptoms of dementia: A systematic review. *Biomed Research International*, 2015.
- [13] Zamfir M, Marin A, Ciobanu I et al. The concept of Dementia Enabling Built Environment from an interdisciplinary perspective. 2020. Argument no.12/2020
- [14] Marquardt G & Schmiege P. Dementia-Friendly Architecture: Environments That Facilitate Wayfinding in Nursing Homes. *American Journal of Alzheimer's Disease & Other Dementias*, 2009, 333-340. doi:10.1177/1533317509334959.
- [15] Chalfon G, Simpson J, Shukla Y et al. Whole systems dementia treatment: An emerging role in the NHS?. *Morecambe Bay Medical Journal*, 2018, 58-61, URL: <https://www.mbmj.co.uk/index.php/mbmj/article/download/35/12>.
- [16] Yorozuya et al. Review of MNPIs for Dementia. *Dement. Geriatr. Cogn. Disord.*, 2019, 48:1–16. doi: 10.1159/000503445
- [17] Guzman-Parra J, Barnestein-Fonseca P, Guerrero-Pertiñez G et al. Attitudes and Use of Information and Communication Technologies in Older Adults With Mild Cognitive Impairment or Early Stages of Dementia and Their Caregivers: Cross-Sectional Study. *J Med Internet Res*, 2020, 22(6):e17253. doi: 10.2196/17253.
- [18] Lazar A, Thompson H & Demiris G. A systematic review of the use of technology for reminiscence therapy. *Health Educ. Behav.*, 2014, 41(Suppl. 1):51S-61S. doi: 10.1177/1090198114537067.
- [19] Zhang MWB & Ho RCM. Personalized Reminiscence Therapy M-health Application for Patients Living with Dementia: Innovating Using Open Source Code Repository. 2017, 153 – 156.
- [20] Ciobanu I, Marin AG, Drăghici R et al. Safety Aspects In Developing New Technologies For Reminiscence Therapy: Insights From The SENSE-GARDEN Project. *Rom. J. Gerontol. Geriatr.*, 2019, 8(1-2): 3-8.
- [21] Serrano J.A. SENSE-GARDEN – A concept and technology for care and well-being in dementia treatment. IET - The Institution of Engineering and Technology. In: Ray PK, Liaw S-T, Serrano JA (eds.). *Digital Methods and Tools to Support Healthy Ageing. Healthcare Technologies*, 2021, 360.
- [22] Woods B, Spector A, Jones C et al. Reminiscence therapy for dementia. *Cochrane Database Syst Rev.*, 2005, doi: 10.1002/14651858.CD001120.pub2. Update in: *Cochrane Database Syst Rev.*, 2018, 3:CD001120.
- [23] Ciobanu I, Draghici R, Marin AG et al. Case Series of an ICT-Based Multimodal Intervention Program for People with Major Neurocognitive Disorders: The SENSE-GARDEN Project. *J Gerontol Geriatr Med*, 2022, 8:137.
- [24] Goodall G, Ciobanu I, Taraldsen K et al. The Use of Virtual and Immersive Technology in Creating Personalized Multisensory Spaces for People Living With Dementia (SENSE-GARDEN): Protocol for a Multisite Before-After Trial. *JMIR Res Protoc*, 2019, 8(9):e14096. doi: 10.2196/14096.
- [25] Assed MM et al. Memory training combined with 3D visuospatial stimulus improves cognitive performance in the elderly: pilot study. *Dement. Neuropsychol*, 2020, 14(3): 290-299. <http://dx.doi.org/10.1590/1980-57642020dn14-030010>.
- [26] McNair D, Pollock R & Cunningham C. *Enlighten: Lighting for Older People and People with Dementia*. La Vergne: Hammond Health Care, 2019.

- [27] Subramaniam P & Woods B. Digital life storybooks for people with dementia living in care homes: an evaluation. *Clin Interv Aging*, 2016, 11:1263-1276. doi: 10.2147/CIA.S111097.
- [28] Martínez-Alcalá CI et al. Information and Communication Technologies in the Care of the Elderly: Systematic Review of Applications Aimed at Patients With Dementia and Caregivers. *JMIR rehabilitation and assistive technologies*, 2016, 3(1):e6. doi:10.2196/rehab.5226.
- [29] Goodall G. Stories from SENSE-GARDEN. Doctoral Thesis, Norwegian University of Science and Technology, 2021, 1-237. Retrieved from URL: <https://ntnuopen.ntnu.no/ntnu-xmlui/bitstream/handle/11250/2788445/Gemma%20Goodall.pdf?sequence=2>.
- [30] Maiken BR, Klingberg T & Petersen KS. The Adult Sensory Profile™ in Care Homes Targeting People Diagnosed with Dementia: A Qualitative Study from the Care Provider Perspective. *Rehabilitation Research and Practice*, 2018, vol. 2018, Article ID 5091643. <https://doi.org/10.1155/2018/5091643>.
- [31] Jones C, Sung B & Moyle W. Assessing engagement in people with dementia: A new approach to assessment using video analysis. *Archives of Psychiatric Nursing*, 2015, 29(6), 377-382. <https://doi.org/10.1016/j.apnu.2015.06.019>.
- [32] Cohen-Mansfield J, Dakheel-Ali M & Marx MS. Engagement in persons with dementia: the concept and its measurement. *Am J Geriatr Psychiatry*, 2009, 17(4): 299-307. doi:10.1097/JGP.0b013e31818f3a52.
- [33] Gitlin LN, Winter L, Vause ET et al. The tailored activity program to reduce behavioral symptoms in individuals with dementia: Feasibility, acceptability, and replication potential. *The Gerontologist*, 2009, 49(3):428-39.
- [34] Kang H. Correlates of social engagement in nursing home residents with dementia. *Asian Nursing Research*, 2012, 6:75-81.
- [35] Jiang L, Siriaraya P, Choi D et al. A Library of Old Photos Supporting Conversation of Two Generations Serving Reminiscence Therapy. *Front. Psychol.*, 2021, 12:704236. doi: 10.3389/fpsyg.2021.704236.
- [36] Livingston G et al. Dementia prevention, intervention, and care: 2020 report of the Lancet Commission. *The LANCET COMMISSIONS*, 2020, 396 (10248): 413-446. doi:[https://doi.org/10.1016/S0140-6736\(20\)30367-6](https://doi.org/10.1016/S0140-6736(20)30367-6).
- [37] Chalfont G, Milligan C & Simpson J. A mixed methods systematic review of multimodal non-pharmacological interventions to improve cognition for people with dementia. *Dementia (London)*, 2020, 19(4):1086-1130. doi: 10.1177/1471301218795289.
- [38] Chapman SB & Aslan S. Shorter term aerobic exercise improves brain, cognition and cardiovascular fitness in aging. *Front Aging Neurosci*, 2013, 5(75).
- [39] Farina M, Rusted J & Tabet N. The effect of exercise interventions on cognitive outcome in Alzheimer`s disease: a systematic review. *Int Psychogeriatr*, 2014, 26(1):9-18.
- [40] Visser H et al. Gait and balance in senile dementia of Alzheimer's type. *Age Ageing*, 1983, 12:296-301.
- [41] Manckoundia P, Pfitzenmeyer P, d'Athis P et al. Impact of cognitive tasks on the posture of elderly subjects with Alzheimer's disease compared to healthy elderly subjects. *Movement Disorders*, 2006, 21(2):236-241.
- [42] Pettersson AF, Engardt M & Wahlund LO. Activity level and balance in subjects with mild Alzheimer's disease. *Dementia and Geriatric Cognitive Disorders*, 2002, 13(4):213-216.
- [43] Kenny AM, Bellantonio S, Fortinsky RH et al. Factors associated with skilled nursing facilities transfers in dementia-specific assisted living. *Alzheimer Dis Assoc Disord*, 2008, 22:255-260.
- [44] Beauchet O, Launay PC et al. Association of hippocampal volume with gait variability in pre-dementia and dementia stages of Alzheimer disease: Results from a cross-sectional study. *Exp. Gerontol.*, 2019, 15:55-61.
- [45] Beauchet O, Barden J, Ambrose TL et al. The relationship between hippocampal volume and static postural sway : results from the GAIT study. *AGE*, 2016, 38, article number 19.
- [46] Makizako H, Shimada H et al. Poor balance and lower gray matter volume predict falls in older adults with mild cognitive impairment. *BMC Neurology*, 2013, 13(1):102.
- [47] Stephen R, Hongisto K et al. Physical activity and Alzheimer disease?: a systematic review. *The Journals of Gerontology Series A Biol Sci Med Sci.*, 2017, 72(6):733-9.
- [48] Lautenschlager NT, Cox KKL, Flicker R et al. Effect of physical activity on cognitive function in older adults at risk of Alzheimer Disease: a randomized trial. *JAMA*, 2008, 300:1027-1037.
- [49] Kemoun G, Thibaud M et al. Effects of a physical training programme on cognitive function and walking efficiency in elderly persons with dementia. *Dement. Geriatr. Cogn. Disord.*, 2010, 29:109-114.
- [50] Rao AK & Chou A. Systematic review of the effects of exercise on activities of daily living in people with Alzheimer's disease. *The American Journal of Occupational Therapy: official publication of the American Occupational Therapy Association*, 2014, 68(1):50-56.
- [51] Mandolesi L, Polverino A et al. Effects of physical exercise on cognitive functioning and wellbeing: biological and psychological benefits. *Front Psychol*, 2018, 9:509.

- [52] Gallaway PJ, Miyake H, Buchowski MS et al. Physical Activity: A Viable Way to Reduce the Risks of Mild Cognitive Impairment, Alzheimer's Disease, and Vascular Dementia in Older Adults. *Brain sciences*, 2017, 7(2), 22. <https://doi.org/10.3390/brainsci7020022>.
- [53] Fuentes-Abolafio IJ, Stubbs B et al. Functional parameters indicative of mild cognitive impairment: a systematic review using instrumented kinematic assessment. *BMC Geriatrics*, 2020, 20:282.
- [54] Ahlskog E & Geda Y. Physical Exercise as a Preventive or Disease-Modifying Treatment of Dementia and Brain Aging. *Mayo Clin Proc*, 2011, 86(9):876-884.
- [55] Marquardt G & Viehweger A. *Architecture for people with dementia: Planning principles, practices and future challenges*. 2015.
- [56] Han JW, Lee H, Hong JW et al. Multimodal Cognitive Enhancement Therapy for Patients with Mild Cognitive Impairment and Mild Dementia: A Multi-Center, Randomized, Controlled, Double-Blind, Crossover Trial. *J Alzheimers Dis.*, 2017, 55(2):787-796. doi: 10.3233/JAD-160619.