Virtual Reality to Stimulate Cognitive Behavior of Alzheimer's and Dementia Patients

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Abstract. Seniority and Alzheimer's and dementia's diseases lead to progressive cognitive impairment. The exploitation of Virtual Reality is investigated to test innovative entertainment and therapeutic activities that can provide new stimuli and interests for patients. The game approach activates mechanisms able to train memory and energize the mind through visuospatial and sound inputs. A full-immersive application has been developed to allow the patient to perform this kind of experience at home for daily training, becoming short therapeutic cycles, thanks to the affordability, the transportability and the flexibility of the infrastructure put in place. The cognitive path foresees successive levels of interaction, alternating relaxing and inspiring settings and exercises. It can improve the quality of life by learning to manage and monitor actions and feelings. In this way, these kind of experience can generate positive benefits not only for those who show fragility, but also for their families in addition to a tool to support health workers for diagnostics and training.

Keywords: Alzheimer's disease, Serious game, Cognitive exercises.

1 Introduction

Nowadays, Virtual Reality (VR) is being extended to several sectors including healthcare and medicine. The main areas of application in these fields concern: training for nurses and caregivers, diagnostics and prevention, and physical and psychophysical rehabilitation [1]. Through the reproduction of virtual models, it is possible to simulate specific processes and scenarios in a realistic way focusing on cause and effect factors. An efficient VR system is able to offer a truthful three-dimensional rendering of human body parts or an avatar that can interact with situations and objects to achieve different objectives depending on the subjects involved. Thanks to technological evolution, the healthcare sector can also innovate towards a forefront healthcare system [2]. The contribution focuses on the creation of virtual reality environments and exercises for patients who are in certain medical conditions. Virtual reality is used to treat a wide variety of medical pathologies, becoming excellent tools to support traditional therapeutic processes. Over the years, several successful applications have been developed for the treatment of phobias, stress, anxiety and post-stroke rehabilitation [3]. The possibility to customize the scenes and activities, to make them more engaging, and to adapt the therapy according to the feedback of patients on performance are some of the advantages of experimenting with new visualization method. According to statistics, in Italy, there are more than 600.000 people with Alzheimer disease, equal to 4% of the population over 65. It is expected that in 2050 the over 65s will represent 34% of the population, making the country one of the most affected. This condition is often accompanied by dementia. According to the scientific community around the world, the case of dementia will tend to increase dramatically, bringing about 152 million people with dementia to 2050 [4]. The loss of cognitive functions such as thinking logically, remembering events of the present and the loss of behavioral skills are the main causes that hinder daily activities. The traditional exercises are usually focused on the simulation of correct daily habits, consequences of addictions and to learn about their prevention and treatment, to develop physical and cognitive exercises for rehabilitation, as well as to create simulations for the treatment of cognitive behaviors and special situations. The use of VR represents an opportunity to innovate the current tools and to enhance particular treatments related to human psychological, motor and cognitive functions [5]. The VR instruments on the market are so advanced and adaptable to every event that they can be professionalized and specialized. Cognitive training based on digital tasks and exercises can be a good solution to involve participants in structured mental activities and improve their cognitive functions, especially if the motivational and playful aspect is emphasized. The serious game presented in this article aims to stimulate emotions and the memory of Alzheimer patients, evaluating the most effective way of interaction.

2 Methodological approach

2.1 Research background

The objective of the study is to test the use of virtual reality for relaxation and cognitive stimulation of patients. The specific contribution is part of a wider research that aims to investigate the conditions that can make the experimentation effective in terms of: pathology, patient target (i.e. age, gender, social background), self-sufficiency (i.e. independent, caregiver-assisted or doctor-guided experience), level of immersivity (full-immersive, semi-immersive) and place where to carry out the experience (i.e. patient's home, dedicated rooms in the hospital or nursing home). From the matrix of combinations that is generated our research is currently directed towards diseases leading to cognitive impairment experimenting different technological systems depending on the context of use. Specifically, it was considered to experience semi-immersive experiences in hospital-healthcare environments, while totally immersive in a domestic environment. This choice can be traced back to the hardware devices to be used. Actually high-performance graphic calculation projection and tracking systems are deployed to obtain a three-dimensional experience with the possibility to focus both on the digital image and on the real objects, images, smells, that surround the user. If the advantage lies in being able to extend the experience to group of users, this mode of immersion is connoted by tools of large dimensions and high costs. Meanwhile the instrumentation for an immersive virtual experience is more limited, easily transportable and affordable, therefore it is easier to install at home. It is necessary to equip the patient with a head-mounted device, sensors for tracking human movement and recognition of the real environment, fast conversion systems to transfer real inputs within the virtual environment. The level of interaction control and the sensation of involvement are incomparable, although wearing the device may not be suitable for all patients.

2.2 Comparison among technologies: Virtual Wall and HTC Vive

In order to assess which technological solutions currently available on the market can be used to achieve the objectives identified in the previous paragraph, a workshop was organized with professionals from different backgrounds, including doctors and nurses. This was an opportunity for experimentation, evaluation and participatory design of virtual reality applications. Among the solutions examined are stereoscopic wall projection system and viewers.

Virtual Wall

Through a semi-immersive system such as the *Virtual Wall*, it is exploit the potential of different tools that generate a virtual environment. It is part of a larger system called *Cave*, using only one screen with projector and two cameras to make the virtual room transportable. The advantage of these technologies is the possibility of using a high precision stereoscopic holographic projector that transmits the three-dimensional model to a screen. The user perceives the three-dimensionality through 3D glasses equipped with reflective markets. With infrared cameras connected to the workstation, the tracking signal is transmitted. The higher the signal accuracy, the greater the user tracking in the surrounding space. By using only two chambers, a fairly large movement area can be covered without signal dispersion. If the environmental and user conditions are unfavorable, the addition of more rooms positioned at the end of the room make the movement more fluid. The problem with this system is the reflective surfaces and the amount of permeable light. If the room is neutral in colors and light, the more the system makes the environment immersive.

HTC Vive

Systems such as HTC Vive or Oculus Rift, are certainly cheap and easy to use. Since the equipment to make the experience immersive is simple and unsophisticated. What affects most in these types of tools is the PC graphics card, because it requires an NVIDIA GeForce GTX 1060. Also in this case the two bases for detecting the user's position present; 360-degree play area tracking coverage, wireless syncing and fits standard threaded mounting point. The headset is equipped with infrared cameras to communicate the movements with the two bases and render the virtual setting with modest frames. In addition, a knob is provided to adjust the focal distance and sharpen the images. Through a regulation system it adapts to every type of user. Finally, it can be integrated with other Virtual Reality systems that monitor limb movements such as overalls or gloves. The feeling that the two systems release is of a total immersion in real time, thanks to an easier use of the controllers. They are currently used for motor rehabilitation in hospital and at home, simulation of surgical interventions, training for doctors. If used for a long time during the day they can generate discomfort such as headaches and dizziness. The new systems have tried to reduce this problems with customizable lenses and using ergonomic helmets for wearing eyeglasses. The cost of this equipment is around 1000/600 €. Fig 1 shows the technical specifications of the two equipment considered.

VIRTUAL WALL	
Projector	
Screen	300x190 cm
Resolution	Full HD 1080p
Refresh rate	120 Hz
Field of view	180 degrees
Cameras	
Resolution	1.3MP @ 240 fps, FOV 82° x 70°
Tracked area requirements	
Room-scale	Up to 9 mq

HTC VIVE	
Headset Specs	
Screen	Dual AMOLED 3.6'' diagonal
Resolution	1080 x 1200 pixels per eye
Refresh rate	90 Hz
Field of view	110 degrees
Controller specs	
Sensors	SteamVR Tracking
Tracked area requirements	
Room-scale	Up to 15 mq

https://www.vive.com/eu/product/#vive%20series

Fig. 1. Comparison of technologies: HTC Vive and Virtual Wall.

2.3 Immersive application for patients' relaxation and cognitive stimulation

In relation to the scenario outlined, an immersive VR application has been implemented for Alzheimer's and dementia patients. These degenerative diseases are characterized by a gradual loss of memory and a deterioration of cognitive functions which, in the most acute phases, can compromise normal daily activities. The goal is to offer an entertainment experience with multi-sensory stimuli useful to reactivate and train the mind of older people through a gamification approach. Many studies have been carried out in recent years in this field, focused on the preservation of residual skills and executive functions through the reproduction of everyday contexts and actions. A walk in the park [6], the search for products on the shelves of a supermarket [7], the execution of a recipe [8], are some activities that require the implementation of choices and strategies. Considering the age of the target group, the activities are designed to take place at home assisted by a caregiver.

Fig. 2 Forest experience
Source: https://youtu.be/cMnia8KprIE

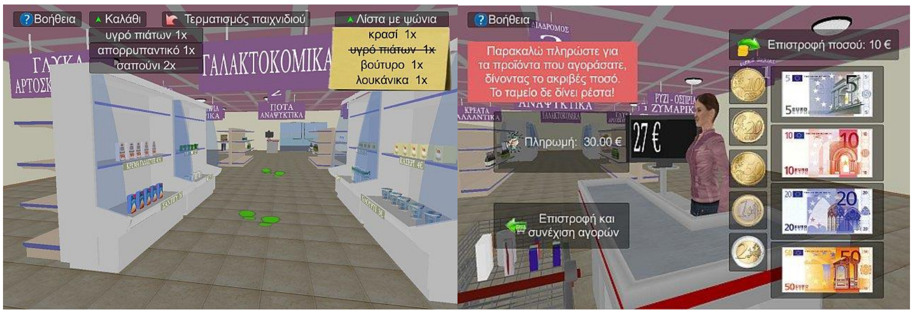


Fig. 3 Virtual supermarket experience
Source: https://www.alzheimer-riese.it/~alzheim3/contributi-dal-mondo/annunci/4413-un-gioco-di-realta-virtuale-per-la-stimolazione-cerebrale-puo-rilevare-lmci-che-spesso-precede-lalzheimer

The application provides a path with gradual levels of complexity in order to test different behaviour and abilities. It is divided in three activities: (i) exploration of relaxing environment, (ii) basic memory exercises, and (iii) advanced memory exercises. The interaction with the patient is also progressive: from an almost passive stage of exploration to tasks that involve observation and recognition of forms, objects, colours and actions to be carried out in sequence.

Development of the virtual environment through gaming platforms

There are different development platforms for Virtual Reality applications. Some of them require a high level of knowledge in terms of programming. In addition to the skills of the developers, it is useful to take into account for the purposes described in the contribution, the graphic detail that can be obtained with these platforms. The software that today meets the requirements described above is Unity 3D, inside it it is possible to generate three-dimensional environments with a high realism thanks to the rendering by frame of the light on the set materials.

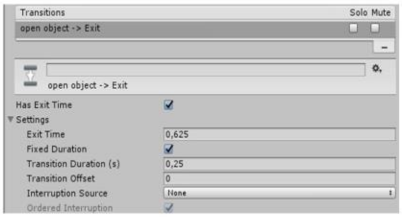
The virtual environment is create by importing the elements, developed with specific software for 3D modeling. In particular, the interoperable format with the platform used for the virtual environment is fbx. This format reduces the meshes of the object and maintaining the element hierarchy after we have assigned the materials.

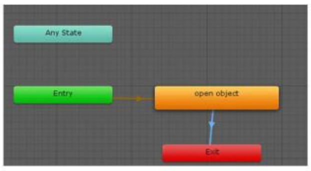
Once inserted the objects in Unity that make up the virtual model, it is useful to set the properties of the materials, lights and realism effects such as wind oscillation in the objects and sounds and animations. Among the advantages that this software offers, we find the possibility to import animated 3D objects, developing a Rigidbody with all the nodes. This skeleton that is created, however, cannot be modified directly on Unity but it is necessary to act on the starting software. For these reasons, Unity maintains an internal interface to create animations on an object from scratch, controlling the different nodes through scripts. Fig. 4 highlights the management of animations through scripts.

Furthermore, the reading of the movements created within the software are more fluid and realistic. The other advantage of the Unity platform, is the import of free packages that the different VR platform developers make available to facilitate interactions via the viewer controllers used. In fact in our case, both for HTC Vive and Oculus Rift, the appropriate packages have been downloaded. To implement the interactions, specific scripts have been studied for each action that recall the basic functions present within the package. In this way, by inserting the actions to the virtual scene and connecting the desired headsets in the setting properties of the VR supports, the executable can generate. This file is independent of the Unity project and can be use in any workstation that supports the minimum requirements required by headsets.

The creation of the virtual scene is quite simple and the hierarchy of the elements is easy to find thanks to the control panels that the Unity project preserves. In fact, through the "Console" bar, the program warns the developer if during the association of the script with the object it is correct or if the code has gaps. The intuitiveness of the software and the online guide that supports developers in the implementation of the code makes the choice of software successful and scalable to every need.

```
using System.Collections;
   using System.Collections.Generic;
   using UnityEngine;

   public class  : MonoBehaviour {

       public GameObject tiger;
       public AnimationClip attack;

       private Animation myAnimation;

     /*  IEnumerator Wait()
       {

           myAnimation = GetComponent<Animation>();
           myAnimation.Play(attack.name);
           yield return new WaitForSeconds(3);

       }
   */
       void OnTriggerEnter(Collider other)
       {
           Debug.Log("Entered Trigger");
           myAnimation = GetComponent<Animation>();
           myAnimation.Play(attack.name);
          // StartCoroutine(Wait());
       }
// Use this for initialization

       // Update is called once per frame
       void Update () {

      }
   }
```





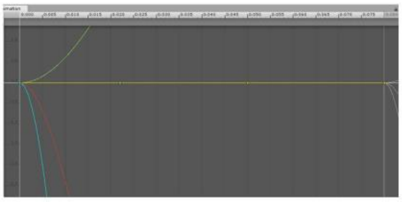


Fig. 4. Example of virtual animation and control by script

First level activity: Exploration of relaxing environment

Like in reality, space design plays a key role in delivering positive experiences for Alzheimer patients, virtual environments can also contribute. In fact, peaceful and comfortable locations can help to reduce agitation and anxiety making users feel good and improving their mood. To achieve this goal, it is important to create scenes in which the colors, light, and sounds are well calibrated in order to return feeling of relaxation. The quality of the setting can engage and delight the user, stimulating reactions and reaction and memories and encouraging communication. As the next level activities require greater interaction and concentration by the patient, the acclimatisation phase is essential to establish an optimal psychophysical condition. In order to test the user's preference according to the specific perception, two settings have been created: a multisensory room [9] and a natural landscape. As visible in Fig. 5, natural elements and animals are used, recalling familiar landscapes and pleasant personal sensations associated with them.

Fig. 5. First level activity. Exploration of relaxing environment.
Source: images from the Carvajal's Master Thesis [9]

Second level activity: Basic memory exercises

The second stage provides for the active involvement of the patient. To execute the *Train your memory by colour, forms and number* exercise it is necessary to become familiar with the joysticks, memorizing the correct buttons to take actions. The activity session is organized by three tasks [9] as illustrated in Fig. 6.

Task 1: Color sequence recomposition.
A sequence of three cubes with different colours is presented to the patient. After observing it, the objects disappear and it is requested to restore the correct order by clicking on them. If the sequence is right, a new sequence to be memorized with a higher number of cubes is displayed to continue the game. If it is not correct, the activity stops and must be restored. The introduction of a timer help the patient to be more stimulated in reaching the goal in the shortest possible time. This activates a competition with oneself, encouraging users to continue playing the game to achieve better results. Each cube contains sub-objects that are used for the construction of the interaction. A script manage and recalls the object's colors and the relative order.

Task 2: Important and current dates composition.
The task concerns the possibility of composing dates, such as birthday, year of marriage, children's birth, current date, in a virtual way. Through editable sliders, the user can select the day, month and year by simply dragging the cursor on the corresponding button. The management of number is effective in keeping the brain active in remembering personal data and keeping in touch with everyday life. The

caregiver can ask to remember other dates or even memorize new ones, training the mind in an alternative mode.

Task 3: Puzzle composition.
The last exercise concerns the creation of a virtual puzzle. There are several choices. The pictures are linked to images that stimulate the memory. For example, a map of the city divided into districts is proposed. The pieces have been reproduced through three-dimensional shapes in brilliant colours so that they are pleasing to the visual senses of Alzheimer's patients. They must be placed on a background that presents the same colour scheme. Puzzles are designed to give a sense of satisfaction to patients when they complete the picture. Each piece is controlled by elements and a script to read the position on the table and associate it with the correct orientation once near the map. This type of exercise in addition to helping the mind can increase the motor functions of the limbs, as if it were a small physiotherapy session led by the controller.

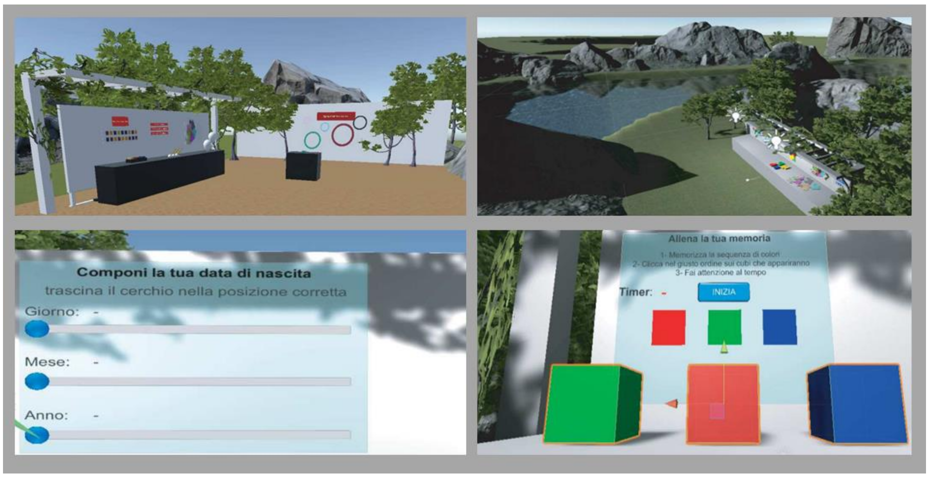


Fig. 6. Second level activity: Train your memory by colour, forms and number.
Source: images from the Carvajal's Master Thesis [9]

Third level activity: Advanced memory exercises

Currently there are several applications related to the possibility of cooking in Virtual Reality. An example is *CyberCook*. It allows users to create recipes from all over the world using real-time virtual ingredients. It allows to learn how to create a variety of international dishes, providing indications for each step of the recipe, up to the cooking. Through a series of techniques and virtual tools, users can execute the recipe by listening to the instructions inside the viewer. The more ingredients are inserted into the pan in the correct way, the expert chef accumulates points to advance the level and unlock more and more complex recipes [10].

Another application with pedagogical function is *Mes crêpes Lactel* presented during the Laval Virtual fair. In this case the user activates a real journey: from the virtual visit of the production plants to the search on the shelves of the virtual kitchen for the useful ingredients to complete the recipe. The peculiarity of this application is the combination of cooking and the teaching function, making the production processes known to the public, such as observing the chemical molecules during the milk preservation process [11].
Thanks Virtual Reality, the users can actively learn the information and through specific tasks involving perception / action, the transfer of knowledge and behavior acquired in a virtual world into the real world can be promoted [12]. According to some studies, excellent results can be obtained, evaluating first the same actions done in real life and then repeating them in virtual. In fact, by associating a global score for assisted autonomy, the patient can obtain modest but significant benefits (15.4% from the virtual, 11.3% from the real condition), reaching scores of 90.8% through Virtual Reality applications and the 94.4% replicating them in reality [13].
By exploiting these potentials, the developed *Train your mind by cooking* application in Fig. 7 can become a useful support for Alzheimer's patients, not only to train the mind but above all to restore the correct functionality to the objects that will be used in everyday life. In this case, combining the game with the passion for cooking, each action is controlled and managed through Virtual Reality. It become a valid support creating safe environments where the patient can make mistakes without impacting on real life. Another objective that this activity wants to highlight is the possibility of transferring virtual actions into everyday life, becoming a valid support for the patient's autonomy. The activities are divided into different steps.

*Task 1: C*hoose the recipe of the day
Using a virtual button, the patient with the operator will activate the list of ingredients on the blackboard and read the activity.

Task 2: Execute the recipe
The user must perform the previously read action and memorize the correct movement. If the activity is not carried out adequately with respect the indications, the ingredient button will not change color and the users cannot continue with the recipe. In this way, movements and actions can be controlled by giving the right value to the object. During the learning process, the user always has the opportunity to read the instructions to strengthen the correct answer, and reduce the production of errors.

Fig. 7. Third level activity: Train your memory by cooking.

Task 3: Interaction with animations

The game is made even more interactive by activating animations. For example, it is possible turn on the stove and hear the sound of the coffee maker. In this phase, other senses are also activated, such as sound and perception of the action in a concrete way. This is thanks to a detailed modeling of the context and animations. Realism is fundamental in educating the patient in the correct use of objects and in the sense of danger. In fact, if during the execution of the recipe, the patient forget to turn off the stove or close the water tap, a second button activate an audio alarm so the patient know that something is not working properly. The study of interactions is basic and does not require great skills to facilitate the use of this system even for those who are not familiar with technologies. In fact, simple actions, such as activating / deactivating the buttons or touching and opening / closing objects are associated with a single button on the joystick. All the actions that the user can carry out have a visual or audio correspondence which facilitates interactivity and can guide in the correct execution.

3 Results and discussion

The application has been realized in an experimental way with the specific objective of formulating an easy to manage experience to allow patients to carry it out at home. Although there is no doubt that the non-immersion mode is the simplest to deliver, the aim is to test whether total immersion can amplify the effectiveness. From a technical point of view, the use of low-cost functional environments such as HTC Vive and Oculus Rift makes it possible to easily distribute the application on a larger scale. The transportability of the system allows to amplify the results achieved in the hospital thanks to the family environment and the actions carried out in the daily life of one's own home. Currently the application has been submitted to about thirty people without disease in a dedicated workshop to evaluate its functionality. Participants' satisfaction is mainly influenced by the correct correspondence between actions and movements. The more the VR system used is correctly calibrated the more the interaction is in real time reducing response times. While it was tested on a limited sample of patients on a voluntary basis. Considering the age of the patients, it emerges that, despite the interest in testing virtual environment, the support of an operator or caregiver available to learn how to use the devices is necessary. On the other hand, the game experience can be configured as a good support to entrust to the caregiver who assists the patient at home. Since the game is divided into several levels, it is possible to calibrate the activities and differentiate the sessions. For example, immersion in a virtual setting is indicated to offer the patient a distraction and calm him/her down, while the exercises are used to stimulate him/her when he/she is more calm. The more exercises are implemented, the more options are available. This new type of treatment has led to the definition of new sensations thanks to the continuous implementation of the virtual environment. In fact, working on realism, the user feels no sense of disorientation. In particular with regard to the recipe, which requires the performance of real-life actions, the main advantage of the training is the error-free learning mode. The user is directed to take alternative measures to solve the problem or respond to inputs from external agents, based on his psychophysical condition. The best way to act on cognitive presence is to formulate very specific questions and requests to the user. In this way the patient always has the awareness of what he/she will do. Verifying the cognitive presence of patients undergoing these types of exercises using virtual reality is essential to ensure progress and improvements in their mental abilities, as well as to determine changes and improvements in the design of applications based on the type of dementia. To implement the effectiveness of this new methodology, evaluation tools called Pool Activity Level (PAL) can be used [15]. These systems help to measure mental and physical progress, and assess cognitive and behavioral independence in the face of unexplored situations. The purpose of the PAL instrument is to allow caregivers to involve people with dementia in meaningful activities, provide information about the individual's strengths and abilities, and ensure that activities are appropriate. It consists of four levels: planned, exploratory, sensory and reflex. Evaluation systems such as the PAL introduce new mechanisms between the patient and the therapist. In fact, to test the effectiveness of the treatment, the therapist needs tools to evaluate the user's history. In this way, the personalization of the treatment can lead to detailing the activities based on the preferences indicated through PAL questionnaires. By working mainly on the exploratory activity, the patient is helped in carrying out common activities in family environments, for example, reproducing his home in which to do the activities in virtual. This facilitates the concentration and the final development of the exercise. This triggers a mechanism such that the sensory stimuli amplify the movements and help the mind to remember thanks to the emotions that the three-dimensional setting arouses.

4 Conclusion and next development

Many studies are ongoing to determine whether the Virtual Reality could be used as an alternative method that alleviate the course of diseases such as Alzheimer and dementia [14]. Initial findings reveal that the patient is attracted to the game approach which allows to carry out the activity with greater motivation and interest. The unique ability of Virtual Reality to transport you elsewhere can be used to simulate increasingly realistic actions and processes. For certain pathologies VR environments can be seen as tools able to develop new mechanisms between patient, caregiver and medical staff, strengthening traditional treatment systems. If the exercises can be studied and calibrated according to the clinical needs of the patients, at the same time the research tries to understand how to make the experiences more and more customized, so as to provide experiences that can evoke moments of their personal, family, and working life. The Virtual Reality application developed and the experience as a whole will be further refined according to the feedback received in order to carry out a real trial considering a well-defined sample target of patients. Tomorrow's therapist will therefore no longer need real environments but will activate virtual travel that will help people overcome their fears and mental deficits. Furthermore, among future developments, Virtual Reality can also be used as a diagnostic tool in the case of Alzheimer's and dementia patients, helping doctors to prevent and constantly monitor the course of the disease. In the coming years, the Virtual Reality will be used to improve the accuracy and effectiveness of current procedures and the capabilities of the human being, both as a caregiver and as a patient.

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References

1. Sik Lányi, C.: Virtual Reality in Healthcare. In: Ichalkaranje N., Ichalkaranje A., Jain L. (eds) Intelligent Paradigms for Assistive and Preventive Healthcare. Studies in Computational Intelligence, vol 19. Springer, Berlin, Heidelberg., 88-16 (2006).
2. Riva, G.: Virtual Reality for Health Care: The Status of Research. CyberPsychology & Behavior, Volume 5, No. 3, 219-225, (2002).

3. Robert, PH., König, A., Amieva, H., Andrieu, S., Bremond, F., Bullock, R., at al.: Recommendations for the use of serious games in people with Alzheimer's disease, related disorders and frailty. Front Aging Neurosci Front, Volume 6, Article 54, (2014).
4. Alzheimer's Disease International (ADI), World Alzheimer Report 2018 The state of the art of dementia research: New frontiers, (2018). https://www.alz.co.uk/research/WorldAlzheimerReport2018.pdf, last accessed 2020/02/11.
5. Buss, B.: Virtual reality training system for patients with dementia. Master Thesis, ETH Zurich, 1-83, (2009), https://doi.org/10.3929/ethz-a-005899172.
6. Moyle, W., Jones, C., Sung, B., & Dwan, T., Alzheimer's Australia Victoria The Virtual Forest project: Impact on engagement, happiness, behaviours & mood states of people with dementia. Griffith University, (2016).
7. Zygouris, S., Giakoumis D., Votis, K., Doumpoulakis, S., Ntovas, K., Segkouli, S., Karagiannidis, C., Tzovaras D., and Tsolaki, M.: Can a Virtual Reality Cognitive Training Application Fulfill a Dual Role? Using the Virtual Supermarket Cognitive Training Application as a Screening Tool for Mild Cognitive Impairment. Journal of Alzheimer's Disease, Volume 44, Issue 4, (2015), DOI: 10.3233/JAD-141260.
8. Steam Homepage, https://store.steampowered.com/app/857180/The_Cooking_Game_VR/, last accessed 2020/02/26.
9. Carvajal, R: Virtual Reality in Treatments for Alzheimer's patients. Master Thesis, Politecnico di Torino, Torino, (2019).
10. X-TECH BLOG, http://x-tech.am/lets-start-to-cook-virtual-reality-cooking-lessons/, last accessed 2020/02/26.
11. HE SPREADER Homepage, http://ghcfrancaise.blogspot.com/2017/04/unusual-lactel-embarks-on-virtual.html, last accessed 2020/02/26.
12. Howland, J. L., Jonassen, D., Marra, R. M.: Goal of technology integrations: Meaningful learning. In J. L. Howland, D. H. Jonassen, & R. M. Marra (Eds.), Meaningful learning with technology, Boston, MA: Pearson, 4th ed., Volume 1, 1–9, (2012).
13. Foloppe D.A., Richard P., Yamaguchi T., Etcharry-Bouyx F., Allain F.: The potential of virtual reality-based training to enhance the functional autonomy of Alzheimer's disease patients in cooking activities: A single case study, Neuropsychological Rehabilitation, Volume 28, Issue 5, 709-733, (2018), DOI: 10.1080/09602011.2015.1094394.
14. Rizzo, AA., Kim, GJ.: A SWOT analysis of the field of VR rehabilitation and therapy Presence Teleoper. Virtual Environ, Volume 14, 119-146, (2005).
15. Dudzinski, E.; Using the Pool Activity Level instrument to support meaningful activity for a person with dementia: A case study. British Journal of Occupational Therapy, Volume 79, Issue 2, 65-68, (2016), DOI: 10.1177/0308022615600182.