

Article

Immersive Environment for Occupational Therapy: Pilot Study

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Abstract: There has been increasing interest in the application of virtual reality (VR) to occupational therapy and rehabilitation fields. This work presents a VR-based city adventure framework designed for occupational therapy. Its concept is based on taking the user to travel around a virtual city, where the motion is powered by the execution of some type of physical exercise, namely cycling in the current example. This framework is extensible and may integrate different goals focused on improving/maintaining motor and cognitive skills necessary for daily activities, mainly through upper and lower limb exercises and mental challenges. This led to the development of an immersive system, which was tested with an elderly sample (15 participants) in a day center and at a retirement home. Usability, satisfaction, performance and side effects were evaluated to understand future applicability and work directions.

Keywords: virtual reality; serious games; user experience; active ageing; occupational therapy

1. Introduction

The topic of physical activity promotion and cognitive stimulation has been widely recognized as being of central relevance for an active and healthy ageing process. It has been demonstrated that continuous physical and mental stimulation in older adults can postpone the musculoskeletal problems and cognitive decline related to ageing and therefore contribute to better quality of life. Health professionals frequently advise elderly people to perform simple daily tasks such as walking, as they contribute to preventing losses both in muscular tissue and, through the piezoelectric effect, in bone density, while the vision, hearing and olfactory systems stimulate the cognitive process [1,2]. In fact, remembering a path and/or finding a way, reading signs or names and relating them to some subjects or memories, or simply triggering long-term memories from images, sounds or smells, contributes to the maintenance of the cognitive functions.

Unfortunately, at an advanced age, people can stay inactive or even immobilized for a long period. Consequently, features such as muscle mass and function decay rapidly, and mobility and independence are severely impaired or lost. The result is a drastic reduction in activity, leading frequently to long periods of sitting in front of a TV screen or sleeping. To explore any possibility of recovering an adequate functionality level, it is very important to perform physical and cognitive activities to regain fundamental skills, and this typically requires the services of health professionals such as occupational therapists. These activities can be executed with an occupational therapist's direct supervision but also independently at home if there is no significant risk.

The current work addresses home-based occupational therapy (OT) challenges through a virtual reality (VR)-based cycling ride around a virtual city, with frequent stops to perform some physical and cognitive stimulation tasks [3,4]. The main goal of this work is to integrate different types of activities that can be used to train or exercise different aspects of the human body in one single application. In this application, the user is able to switch from one task to another, while the environment, the interface logic and interaction remain mostly unchanged, maintaining therefore the necessary consistency among the interaction elements and therefore improving the user experience. Additionally, specific parameters from the application tasks can be stored in a cloud database for later performance evaluation [5].

The system is a tool that occupational therapists can use in their intervention with elderly people in order to improve, regain or maintain motor and cognitive skills necessary for daily activities. It intends to offer a serious gaming experience including different objectives: physical exercise (head/neck, upper and lower limbs); cognitive tasks involving orientation and memory, such as following a path and signs, or calculations; performing tasks of fine motor control, like shopping pre-defined quantities and, finally, the possibility of choosing between movies in a cinema, where it is possible to select between old movies from his/her youth or recent ones.

The purpose of this pilot study was to evaluate the usability, satisfaction, overall performance and adverse side effects of the application for a better understanding of its applicability and for future work directions of the current project. The work discusses a framework to be used in the rehabilitation field, particularly in OT, since these professionals focus on using meaningful activities to improve functionality, but the authors first need to understand the basic application requirements and implications before further developing the framework.

Section 2 discusses the fundamental ideas and concepts of the project. Section 3 describes the developed immersive environment. Section 4 presents the case study, the methodology and the sample characterization and, finally, the results. This section embodies the focus of the present work, centered on the concept validation, and, simultaneously, provides the authors with content for future work. Section 5 synthesizes the conclusions.

State of the Art

In recent years, there has been an increasing number of studies regarding the benefits of using VR in therapy, namely the features that enable the creation of an environment that motivates the patients to engage in therapy at home. Lin et al. [6] describe the benefits of using VR to improve the motivation of patients recovering from a stroke while engaging in home-based therapy. Given the fact that daily usage and high number of repetitions are key aspects for a better outcome of the therapy, this VR application was identified as potentially increasing the effectiveness of therapy service when conducted at home. Additionally, Levin, 2011 [7] identifies the need to create some intense repetition-based activities for motor recovery and VR is identified as an effective tool to design these environments.

Kober et al. [8] refers to the use of VR in the neurologic rehabilitation of spatial disorientation. The results of this work show that VR can help in increasing the performance of spatial abilities in neurological patients with spatial disorientation and, as well, in healthy users. Results show that, over the five training lessons, participants learned and recalled different routes.

García-Betances et al.'s [9] work discusses the usage of VR in cognitive training of the elderly and improving the quality of daily life activities of people with mild cognitive impairment and Alzheimer's disease. Cognitive rehabilitation can be attempted by two main schemes, known as restorative and functional approaches. Both schemes can be applied to patients during the first stages of Alzheimer's disease and mild cognitive impairment. Results of this study suggest that VR can increase the therapy availability, access to real-time data and feedback from the patient's usage of the application and create an environment specific to each patient's needs.

A systematic review of VR in rehabilitation and therapy [10] creates a discussion around the usage of VR in rehabilitation and therapy by covering a list of potential benefits and challenges to current

and future use of this technology. Some of the benefits [10] identified are as follows: gaming factors enhance motivation; self-guided exploration and independent practice are enabled, and VR helps to create hierarchical delivery of stimulus challenges across a range of difficulty levels. On the other hand, the perception that VR will eliminate the need for the clinician and how to minimize side effects (such as cyber sickness) [11] and interface methods that fail to foster lifelike interactions are some of the challenges that the authors identify.

Like all the VR applications described above, most of those currently available and used in therapy have the purpose of treating only one single problem relating to either the physical, cognitive or mental state of the patient.

2. Work Concept

2.1. Principles Supporting the Work Idea

As a consequence of the present pandemic situation, people have been forced into daily stress and physical activity limitations that contribute to neglecting the relevance of exercise and stimulation, which can later in life have a negative impact on cognitive, emotional, physiological and physical states [12,13], increasing the probability of frailty and disability at an elderly age. Additionally, other negative associations with physical health and motor skills may appear. Moreover, different studies show that preserving a better cognitive state is related to regular exercise [14,15]. Furthermore, participating in intellectually challenging activities during the course of life is also important in order to improve cognitive reserve and to maintain cognitive health in elderly age.

As stated in [16], old age is not too late to participate in challenging activities and improve our health and functionality so as to prevent several age-related problems. OT can be important in defining the correct activities and exercises that individuals can perform safely to improve their overall quality of life.

OT can be conducted either at health/social institutions or, in some cases, simple exercises can be recommended by the occupational therapists to be carried out at home [17,18]. However, home-based therapy sometimes does not have the expected outcome, mainly due to insufficient commitment, which can be due to multiple factors including lack of motivation, either because there is no sense of progress in a small timeframe or because the exercises can be monotonous and repetitive. At home, people might prefer to watch television, for example. Additionally, some OT services can be overcrowded, making the immediate necessary therapy postponed, compromising a possible full recovery [19,20].

VR can help in some of the problems described above by increasing motivation for performing the exercises or increasing patients' autonomy in their therapy, with the additional benefit that dedicated VR applications can either be available in institutions or at home. Another strong feature of VR applications is that it can include patient activity tracking, making it possible to gather quantitative evidence to evaluate the patient's performance, helping the therapist to perceive their progress and change the therapy plan accordingly. VR can be used as a single method or in a blended approach towards rehabilitation.

Increasing patient autonomy in rehabilitation can be also significant in pandemic situations, e.g., COVID-19, where social distance is recommended and people are compelled to stay at home rather than going to rehabilitation centers. In this context, VR applications or tele-rehabilitation can be of great value, making it possible for the patients to continue their exercises and keep track of their performance and evaluation without being dependent on the therapist. The 24/7 availability of therapy is also one of the benefits of engaging in these activities, overcoming some of the OT shortfalls.

2.2. Proposed Concept

The current work aims to contribute to OT resources by proposing the use of a VR framework, consisting of a virtual city that supports the integration of different activities by means of additional

modules. Each of these modules/tasks may be placed at selected locations within the city to create an additional playful space or activity that will provide specific classes of physical or cognitive stimuli. This is in line with one of the commonly used retention strategies frequently explored in video games. In the current VR framework, besides supporting therapeutic specificity, it also enlarges activity diversity, therefore reducing the monotony and increasing the motivation for the proposed OT. Additionally, it enables an open and target-based approach by challenging the patients to progressively adjust the performance to their needs, which, in turn, are consistently and gradually overcome. As a result, VR supports a training program aligned to the patient's needs in one moment but then adjusting to the next step of the therapy. While aiming for daily usage, or as otherwise recommended by the occupational therapist, the patient will follow a game-based approach where leveling up is both motivating and a tactic to assess the effectiveness of the proposed therapy plan. Data from the users' performance can also be stored to be analyzed by therapists or by machine learning-based algorithms that will leverage the difficulty on the tasks, taking into account his/her performance recordings. The potential to encourage competition between groups of OT patients is also one of the benefits of this approach, serving to motivate the patient and helping the therapist to create a group dynamic.

In the proposed concept, the work aims to help in different types of rehabilitation, which can include physical activity or cognitive stimulation to help maintain or improve the patient's situation. All different tasks available via some different spots spread around inspire the user to navigate from one to the other, throughout the virtual environment and at his/her own pace.

Each of the tasks will be designed according to its specific therapeutic purpose, which can be the stimulation of cognitive functions like perception, spatial orientation, executive processes or others. These can be achieved in several ways, such as creating environments to offer the user references to music and movies; creating landmarks and asking the user to identify a specific mark or color in the area; creating road signs or road marks to ask the user to follow a specific path or presenting a map of the virtual environment and telling the user to go from point A to point B. Alternatively, tasks may be used to encourage the user to perform some type of physical activity. In this case, the activity must be tracked and represented in the virtual world. These tasks should consist of simple movements that can be quickly interpreted, with simple to no explanation to the user. We suggest tasks like walking, riding a bicycle or raising and lowering the arms, with a quick real-time simulation in the virtual world and a possible avatar.

3. Materials and Methods

3.1. Software Tools and Development

Based on a generic 3D city model, work was developed in order to optimize its complexity using Blender (<https://www.blender.org>). This program was also used to create the collision mesh to be applied to the model. Finally, these two meshes were integrated together in the Unity (<https://unity.com>) game engine. The Unity software package supports physics simulations, integration of interaction hardware and the development of the 3D virtual city as a VR application. Its libraries simplify the integration of the head mount display in what concerns the visualization of virtual objects according to the user movements and a pair of touch controllers and their associated constellation sensors to track hand movements.

To promote physical exercise, a pedal system was integrated with this VR environment. A Bluetooth sensor was attached to the main axis of the pedals, enabling the integration of the activity-related data into the application. The velocity at which the user is pedaling and their direction (forward or backward) are then used to animate the user's movement.

To prevent dizziness and nausea while using the application, some aspects of the user interaction were taken into special consideration, such as having a minimal amount of text or making some objects bigger than normal [21], but the main change was to make the users tilt their head while making a turn during movement around the streets of the city. Tilting the head more than 10 degrees, to either left or

right, will make the user start turning to the desired direction, and the bigger the angle, the faster the turn. The choice of this type of interaction is inspired by the natural way that people tend to tilt their bodies and heads for performing turns while riding a bicycle.

3.2. The PeViC Application

The application “Pedaling in a Virtual City—(PeViC)” aims to create cognitive and visual stimulation while the user is performing physical exercises. Among the possibilities, the choice was made to explore a bicycle ride for promoting exercise and centering the interaction metaphor of the application, as it is familiar for most people and may bring memories of joyful moments of the past. More than taking the user on a tour through the city, the application enables the user to explore the city, following his/her curiosity. To stimulate this curiosity and to contribute to engaging the user in an exercise that will enable traveling and simultaneously provide cognitive stimulation, the user has goals to be reached. In this game, the user will search for specific tasks, locating and performing them.

The sit-down pedal that can be seen in Figure 1b, is a traditional piece of low-cost rehabilitation equipment and is recommended by occupational and physical therapists for patients’ home use in order to keep their legs active while watching television, for example. One of our decisions for our design was to use some universal and low-cost equipment—in the present case, the pedal system—integrated with VR to increase motivation in its use, combining physical exercise with cognitive stimulation, which is crucial to reduce cognitive decline and prevent dementia. The decision to target this device was based on its price, portability, usability and safety. The rejection of the treadmill and option for the pedal was based on the inadequacy of the former for many potential users due to physical limitations related to the ageing process and safety concerns, whereas the sit-pedal is usable and safe for most of them. Furthermore, the similarity of a sit-down pedal to riding a bicycle can elicit memories and skills associated with a familiar vehicle for leisure or for transportation while ensuring the individual’s safety.



Figure 1. (a) Example of a task in the virtual city; (b) Example of using the application.

The game interaction is carried out via a sit-down pedal and an Oculus Rift with its touch controllers. The user, to be able to make the bicycle move forward, needs to pedal, and the speed at which the user is pedaling is sent to the application via a Bluetooth device. The Bluetooth sensor used to measure the pedaling cadence and speed was a traditional and low-cost electronic unit that can be attached to any bicycle; in this case (Sunding SD-518), one which is easily adaptable to the traditional pedal.

To improve cognitive simulation while riding the bicycle, there are different signs spread around the city to inform the user of the direction that he should follow in order to reach his destination. Other simple physical stimulation implemented was the head movement, to take advantage of the VR hardware. The Oculus Rift is the component responsible for creating the immersive environment and for enabling the user to observe and explore the surrounding environment, where the user can look

around and sight-see while riding the bicycle, and in order to turn either left or right, the user can simply tilt his head in the direction in which he wishes to turn. Tilting the head is also very important to help reduce the motion sickness induced by VR, since it is our natural instinct to tilt the head when turning while riding a vehicle [22]. The use of the touch controllers provides the user with the capability for virtually handling and controlling tasks in the environment by moving his/her hands in the real world, enabling them to explore and interact in a more active and realistic way. The application requires that users hold both touch controllers and use the head mounted display (HMD). This is the reason that it is necessary to have the user tilt his head to make turns instead of using a steering wheel, for example. Otherwise, the user would need to alternate between holding the touch controllers and grabbing the steering wheel while wearing the HMD and vice-versa, in tasks where he/she needs the touch controllers. Therefore, this approach was implemented in order to minimize the lack of familiarization with the VR equipment and make the adaptation period as short as possible.

To avoid confusion and frustration, small clues will guide the user's path in the initial steps. Later, if the user gets lost or takes more than a certain amount of time, arrows can be shown to direct the user to the next point. Depending on the user abilities and choices, the game may propose more elaborate tasks in locations that the user has to visit in order to accomplish the set of defined tasks. Examples of these simple tasks are shopping in a fruit street market for a predefined number of fruit pieces (see Figure 1), going to a music store to select a number of CDs, etc.

To direct the user from the first to the second task, there is a predetermined path, which is indicated via green or yellow arrows, whose meanings will then be explained to the user before using the application. The green arrow-marked path is easier: its length is shorter and there are less turns that the user needs to make in order to move on to the second task. The yellow arrow-marked path is longer: it requires the user to pedal more and make more turns, which leads to the need to tilt the head more often and faster. This makes the task significantly harder for the target group.

Besides the physical training of leg and arm muscles, the tasks aim at recalling some familiar activities that may activate positive memories and emotions and stimulate cognitive functions such as perception, spatial orientation and executive processes.

For cognitive stimulation, other tasks are also implemented, such as shopping for fruit or going to the cinema (see Figure 2). In the shopping task, the user is requested to buy a specific amount of fruit of different types. Therefore, he/she has to select the fruit, pick it up and buy it as he/she used to do in a real shop. To accomplish these tasks, he/she uses the touch controllers associated with the HMD to track the hand position and to represent them in the virtual world. This allows the user to interact with the virtual world like in the real world, also forcing him/her to perform physical activity using the upper body limbs. Going to the movies might also help to create memory stimulation. Since the target population of the study was a group of senior citizens, old movies were used in this version of the application.

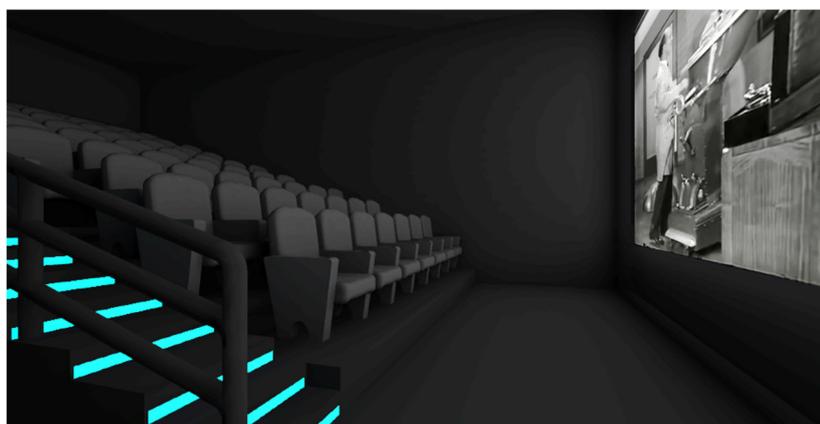


Figure 2. Example of the movie theater.

In the current state of the framework, these are the tasks that were implemented, and a small pilot study was carried out in order to perceive the acceptance of VR, the framework and the tasks already implemented in a small elderly group. This was aimed at understanding the participants' interest and acceptance in order to better define and continue with further development as well as the use of technical features which in the future may increase the usability of the system.

4. Pilot Project

4.1. Description of the Case Study

The study consisted of two parts: use of the system and questionnaires. The participants were asked to use the PeViC system and to answer a questionnaire before and after having used it in order to determine some side effects that frequently may result from the use of VR. The applied questionnaire was the simulation sickness questionnaire (SSQ) [23].

The conducted study [24] describes the measurements of the cyber sickness effect caused by different sources and refers to a strong association with the field of view and the navigation. At present, a training phase is not considered relevant for attenuating this problem. In any case, due to time restrictions, this was not possible to perform.

Before the activity, the SSQ was conducted. After, it was explained how to use the system, and the objectives of the study and of the developed PeViC system were communicated to participants. The conceived activities consisted of performing two consecutive tasks: first, riding a virtual bicycle through the streets of a city; then, going shopping in a fruit street market. To finish, the last task includes a new SSQ, with a few extra questions regarding the use of the PeViC system.

4.2. Methodology and Participants

A cross-sectional study was conducted using a non-probabilistic sample of 15 elderly individuals (73% women; between 61 and 88 years old; mean age of 77 years). Participants volunteered after information regarding the study was disclosed in two local community institutions (a social center and a nursing home). Volunteers had to be at least 60 years old and could not have severe motor or cognitive deficits. Data collection was carried out in September 2019 by a trained researcher. Each institution's review board approved the study and all participants gave their written informed consent.

Conducting the study about the application use and data collection through the SSQ, there was no previous training period, either with the HMD, the touch controllers or the sit-down pedal equipped with the Bluetooth device.

To collect the SSQ data, the questionnaires were presented before and after the use of the PeViC system.

The results collected before and after participant activity were then compared. The activity was performed in periods of 15 min per person, where the participants needed to conduct two different tasks. In the first, the participant rode a bike around a city, using the sit-down pedal and the HMD. The objective of this task was to let the participant choose from two different predetermined paths represented by green or yellow arrows, after being informed that the green path was shorter than the yellow one. Then, the bicycle ride ended in a typical street market stand. The decision regarding which path to take was freely made by the participant. Participants in this task needed to be pedaling with a constant rhythm in order to move forward. To make turns and change moving direction, the user just needed to tilt his head by around 10 degrees in the desired direction (to turn left, tilt the head left; to turn right tilt, the head right, as normally happens when riding a bike) and carry on pedaling to make the bicycle follow the path. The second task was shopping in a fruit market. Apples, pears, bananas, strawberries and kiwis were the available fruit options.

For shopping in the street market, the user needed to also use the Oculus Rift touch controllers. The first task was to pick up the shopping basket, and then the following task was to collect the required fruit pieces, according to visualized recommendations (how many bananas, apples, ...). In the end,

the user had to drop off the basket at its marked location. With the touch controllers, the user simulated his/her virtual hands within the immersive environment and by pressing the correct buttons could grab or drop either the shopping basket or the fruit pieces.

Four of the fifteen participants did not feel able to perform the full exercise; once they started to feel severe nausea while using the HMD, the test was immediately aborted.

4.3. Results and Discussion

All the participants had little or no knowledge of the technology involved in this system, never having been in contact with an HMD or touch controller. The group of participants never had experienced any type of VR environment. To conduct the study, there was no training period for familiarization, which revealed some difficulties for the participants in using the devices, especially the touch controllers. These adversities turned the fruit market shopping into a difficult or extremely difficult task. A training period for the participants was desired because the required task was particularly difficult since none of the participants had ever used the Oculus Rift or the touch controllers (needed to grab a piece of fruit or the basket). The lack of familiarization with the device, combined with using the HMD, led to difficulties in knowing the necessary button positions. Furthermore, this task demanded fine motor skills without visual support, which can limit performance. However, at the time that the tests were performed, the training sessions were not possible due to time constraints.

Nevertheless, most of the participants showed quick adaptation to the first task controls, which included using the sit-down pedal and the HMD, performing well: 100% of the participants chose to go through the easier path, represented by the green arrows.

The study started with 15 participants, but due to physical and perceptual limitations, four were not able to finish. From the 11 participants that concluded the tasks, nine of them enjoyed using the PeViC system, revealing that they would happily use it in OT activities with the help of local staff.

All participants easily recognized the created virtual environment and all the elements present during its use, like arrows, streets, sidewalks, buildings, lamp post, fruit stand, fruit pieces and shopping basket.

To perform an evaluation of the discomfort created by this system in the participants, the SSQ was used [21,25]. The answers to this questionnaire were given on a 4-point Likert scale and the results can be observed in Table 1. Two additional questions were added to evaluate the perceived difficulty of the controls used in the two tasks through a 3-point Likert scale, whose results are shown in Figure 3.

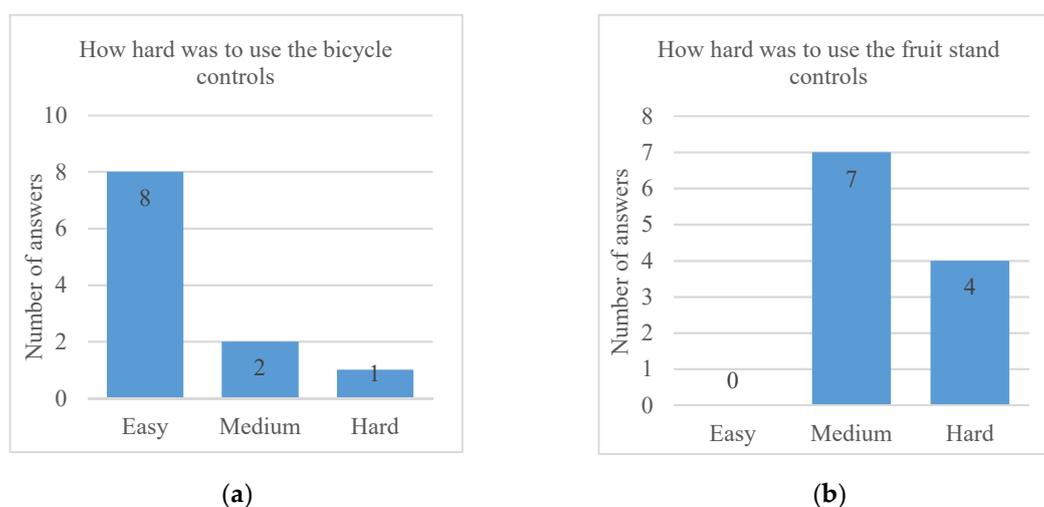


Figure 3. (a) Results of questionnaire regarding bicycle controls; (b) Results of questionnaire on fruit stand controls.

Table 1. Results of the simulation sickness questionnaire.

	Levels	Experimental Session	
		Participants before n (%)	Participants after n (%)
General discomfort	Not at all	8 (73)	6 (55)
	Slightly	3 (27)	4 (36)
	Moderately	0	0
	Very	0	1 (9)
Fatigue	Not at all	9 (82)	4 (36)
	Slightly	1 (9)	5 (45)
	Moderately	1 (9)	1 (9)
	Very	0	1 (9)
Headache	Not at all	7 (64)	7 (64)
	Slightly	2 (18)	2 (18)
	Moderately	2 (18)	1 (9)
	Very	0	1 (9)
Eyestrain	Not at all	6 (55)	6 (55)
	Slightly	2 (18)	2 (18)
	Moderately	2 (18)	1 (9)
	Very	1 (9)	2 (18)
Difficulty focusing	Not at all	5 (45)	5 (45)
	Slightly	5 (45)	4 (36)
	Moderately	1 (9)	2 (18)
	Very	0	0
Nausea	Not at all	11 (100)	7 (64)
	Slightly	0	1 (9)
	Moderately	0	2 (18)
	Very	0	1 (9)
Fullness of head	Not at all	8 (73)	7 (64)
	Slightly	3 (27)	1 (9)
	Moderately	0	3 (27)
	Very	0	0
Blurred vision	Not at all	8 (73)	7 (64)
	Slightly	1 (9)	1 (9)
	Moderately	2 (18)	3 (27)
	Very	0	0
Dizzy (eyes open)	Not at all	8 (73)	6 (55)
	Slightly	3 (27)	4 (36)
	Moderately	0	1 (9)
	Very	0	0
Dizzy (eyes closed)	Not at all	7 (64)	6 (55)
	Slightly	3 (27)	3 (27)
	Moderately	1 (9)	1 (9)
	Very	0	1 (9)
Vertigo	Not at all	7 (64)	6 (55)
	Slightly	2 (18)	3 (27)
	Moderately	2 (18)	2 (18)
	Very	0	0
Stomach awareness	Not at all	10 (91)	9 (82)
	Slightly	1 (9)	1 (9)
	Moderately	0	1 (9)
	Very	0	0
Burping	Not at all	6 (55)	6 (55)
	Slightly	5 (45)	4 (36)
	Moderately	0	1 (9)
	Very	0	0

Fields in which there was no change from before to after were omitted from the table.

According to the results presented in Table 1, there is a global increase in adverse symptoms associated with the use of the system, with some components, such as nausea and fullness of head, increasing from none/slight to moderate/severe in some cases. However, most of the symptoms were absent or mild, and no expressive differences between pre- and post-usage were found.

The increase in the SSQ score might be related to the lack of repetition and familiarization with the tasks, equipment or virtual environment [26].

In terms of the perceived value, the results of Figure 4 are reasonable and the transmitted intention of use was also encouraging [27].

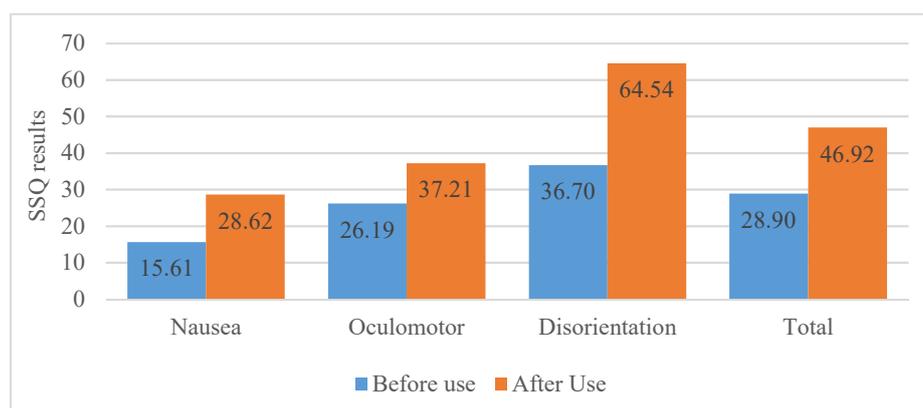


Figure 4. Results of the SSQ conducted before and after use of the application.

The PeViC immersive system was tested in an elderly population from two institutions: a day center and a retirement home. Usability and satisfaction, game activities and side effects were evaluated for understanding the functionalities, applicability and future work directions.

From all the participants that concluded the study, the overall acceptance in using the application was good. Participants were immersed in the virtual environment and engaged in the application, most of them revealing that they would use the application if available in their institution.

The observed increase in the SSQ score can be related to different factors: participants did not have time to adjust to the system before its use, never having been in contact with VR technology or this application. Since one of the main factors to reduce cyber sickness induced by VR is to have the participants repeatedly use the same application [28,29]; a second and possibly a third study with the same group of participants should be conducted in order to allow further analysis and comparison of the SSQ results and to better understand the main causes of the induced side-effects.

5. Conclusions and Future Directions

This work proposed an immersive framework for increasing the engagement of elderly people in different types of stimulating activities, with the main focus on physical exercise. The present prototype supports leg exercise, arm movement, fine hand movement skills and cognitive stimulation tasks. On the cognitive side, the stimulation is obtained while following a path or performing the selected fruit shopping task.

A pilot test was conducted aiming at analyzing users' acceptance and pointing out problems and needs. It was oriented to understand the interest of participants, in order to carry out further development and the use of technical features that will increase the system's usability and create a more user-friendly environment. Additionally, considering the age range of the participants in the study, which was 61 to 88, it was also important to understand their acceptance and how well could they adapt to the application and the technology.

The results are encouraging, but it is clear that a larger study, including a bigger sample, will be needed for deeper conclusions on the application efficacy as well as on its final achievable performance.

In terms of future work, the authors intend to add other tasks more related to hobbies, helping to increase memories and renew interests.

Other possible features to be implemented, to target other types of stimuli, would be based on creating walking routes through the city or even establishing meeting points in the city and allowing the user to rely on his sense of orientation to reach his destination using a map; creating landmarks or places of interest and asking about specific details (colors, markings); placing road signs in the streets and asking the user to follow the traffic rules.

Future studies should analyze participant engagement and the PeViC system effect through physiological measures and increases in patient performance after multiple sessions.

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