VOL. 12, NO. 5, MARCH 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

PROTOTYPE FOR COGNITIVE STIMULATION IN ELDERLY

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ABSTRACT

The deterioration of cognitive functioning in elderly creates obstacles to the proper performance of their daily tasks. In this work, a prototype of stimulation of visuospatial cognition and memory was designed and developed. The prototype consists of an electronic circuit, able to measure the force of grip of the hand and the tilt of the same. The electronic device was covered by a layer of silicone, to give a natural appearance, with the aim of minimizing technophobia in users. The circuit plays the role of controller for a graphical interface developed in Matlab ®. With this, it is expected to stimulate the working memory and the visuospatial cognitive ability in the elderly. This allows the user to familiarize him with the technology and help him to preserve and train visuospatial memory, fostering a greater autonomy.

Keywords: visuospatial cognition, deficits cognitive, senile dementia, virtual interface, working memory.

1. INTRODUCTION

Senile dementia is a clinical syndrome that brings together multiple cognitive impairment symptoms, including foolishness, lost of spirit, changes in personality and other symptoms that may interfere with the daily activities [1], [2]. These symptoms are present with different intensity levels and they manifest themselves progressively with age [3],[4]. A treatment has not yet been found that be totally effective, reason why, until now it is only possible to carry out an adequate promotion and prevention of this clinical condition [5], [6]. Currently is estimated a total of 35.6 million of people with this syndrome, which is a major health problem for today's society [4].

A cognitive map is a spatial representation, which can be created mentally, from a point of reference, a route and a measurement. These can be evoked by the visuospatial memory [5]. Two of the cognitive functions, which are affected in senile dementia, are memory and objects cognition. To prevent impairment of these two functions, a virtual stimulation is performed for short-term memory and cognitive maps for long-term memory [XX].

When cognitive ability is exercised, it is possible to prevent the deterioration of these abilities, which have been acquired throughout life by the patient [9], [10]. This was demonstrated through clinical tests conducted at the Center for Scientific Studies (ARWIG, Germany). In this demonstration, activities were used, involving the senses, the memory of the past, the recognition of people, objects and daily exercise [6].

Another way to stimulate memory in people is through computerized cognitive training, speech therapy, artistic therapy, reading and logical games [7]. In these types of training, it is required the accompaniment of the caregivers to facilitate the understanding of the instructions by the patients, so that they do not become disoriented when they do not encounter familiar faces. [8]

To support the patient, by the relatives, the personnel in charge or on their own, some electronic devices have been developed, which help to exercise the memory. In Japan, for example, a robot has been developed whose function is to talk with the patient to collaborate in the prevention of senile dementia [9]. There are also welfare systems such as smart houses, gestual recognition and specialized media [13].

However, these projects have focused on meeting practical needs or cognitive training only, obviating the lack of social interaction that have the elderly with Alzheimer, being the most frequent pathology that causes senile dementia, which is about 60% to 80% [14], [15]. Also, these projects have modern and technological aspects, which do not consider the possibility of generating technophobia in users [10, 11].

For the above, the objective of this work was focus on the design and development of a tool, which helps to prevent the senile dementia, through cognitive exercise. It could be done in the home of the users, from a computer, with updates of the content carried out from distance by their relatives, with a device that does not have electronic aspect to reduce the technophobia. With the development of this project, it was intend to stimulate the working memory, providing clues to remember familiar places and faces of their relatives, reducing the disorientation of people.

2. METHODS AND MATERIALS

To stimulate memory and induce the user to create cognitive maps, a virtual program was developed using MatLab ® 2012 version, where the user was guided by a virtual navigation, conducted on a regular place for himself (This was achieved with the manipulation of the KML file).

In addition, the family of the user was requested to provide videos recorded by themselves and KML files primarily. These must be loaded to the cloud in the software OneDrive of Microsoft ® to allow file updates. (See Figure-1)

The recorded videos were used to guide and motivate the user, visualizing at the beginning, middle and the end of the exercise. While KML files contain spatial coordinate data, to recreate questions about visuospatial orientation and locations that can recognize from the way. These were generated through the journey that was created in Google Earth ®.

Because specific files need to be prepared, an instruction manual has been developed to facilitate family members to generate routes and virtual spaces that will help the patient to remember and strengthen their memory. For this it is necessary that the relatives or caretakers have a basic level of knowledge in computer science [12].

To simplify the maneuver of the program developed, a wireless device was built, which measures the tilts of the supporting hand. In this way the program interprets the lateral movements of the wrist, to detect the response option selected by the user. This may advance the simulated activity and follows the path of their usual environment, programmed by their relatives (See Figure-1).

The device or the physical and electronic component of the prototype consists of a double-layer PCB that forms the basis for correctly connecting an Arduino Nano, an analog accelerometer MMA7361 type, a bluetooth module HC-05, 2 force sensors (FSR) and 2 batteries in serie of 3.7v.

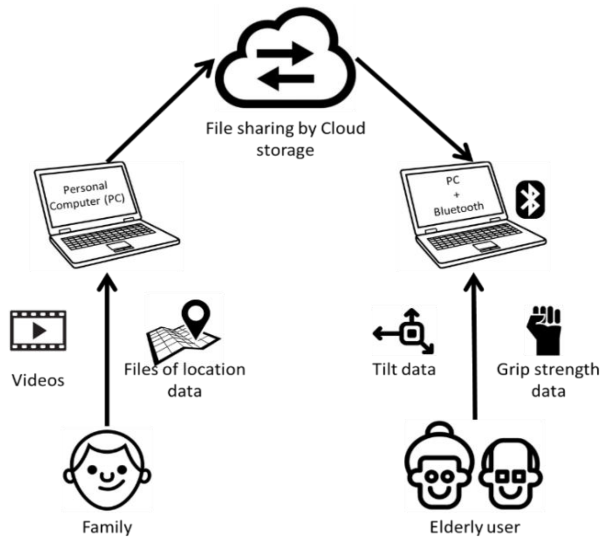

Figure-1. General scheme of prototype operation.

The device has a total output voltage between 7.4v to 8v on the batteries in serie, the voltage was maintained at 5v with the implementation of a voltage regulator LM7805 in the circuit. Force sensors measure the grip strength of the hand in the 10-bit reading range, ranging from 0 to 1023. Due to they measure up to a maximum of 20N [13], and the standard grip strength for older adults may exceed 200N [14], a structure to absorb the surplus strength was designed. This requirement favored to decrease the electronic aspect, to avoid technophobia. (Figure-3)

Therefore, the electronic circuit was stored with polyurethane foam ball pieces, coated with a siliconetoy layer, in which 2 force sensors were placed. Finally, the elastic toy was covered with another layer, as shown in Figure-2, achieving a non-electronic appearance.

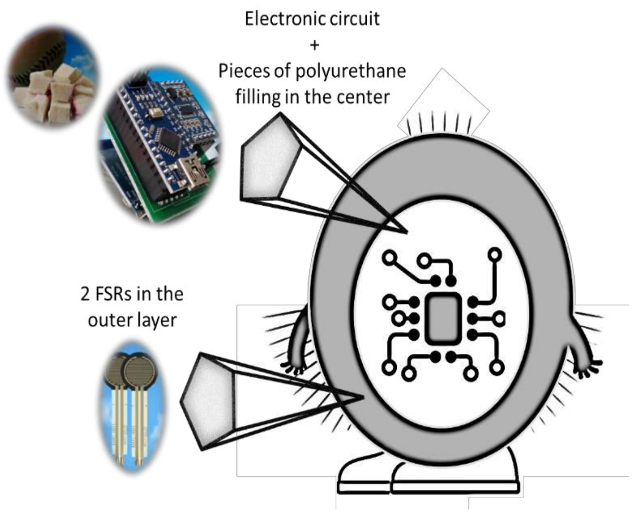

Figure-2. Schematic representation of the device.

In addition to the force measurement, the tilt was measured with the accelerometer on the Y-axis. This is due to in the rotation of the device, significant changes can be recorded from -250 to 220 units, with a change of 50 units every 45 degrees of tilt approximately, which allows to identify the turns to the right or to the left. (See Figure-3 andTable-1)

Figure-3. Final device.

Table-1. Digital interpretation of tilt in the device.

Digital interpretation in the device		
Position	**Interpretation minimum digital**	**Interpretation maximum digital**
Center	1	10
45-degree tilt to the right	165	170
90-degree tilt to the right	220	226
45-degree tilt to the left	-170	-183
90-degree tilt to the left	-241	-252

The tilt and force information was sent to the virtual serial port of a computer with Bluetooth module, which can finally be read in the program developed in Matlab. All questions to be executed in the program, offer 2 options of answer located in the sides (Right and Left), so the user must choose one of them, with the movement of his wrist turning the device with him.

The program begins with the playback of an introductory video (see Figure-4), one of them, is an animation that explains the methodology for reaching the goal of navigation and indicates how to use the prototype.

The other video was the recording made by family members, which repeats in their own words the instructions on how to reach a selected target. There were 2 more recordings with these characteristics, in order to remind repeatedly the established goal of the displacement. In this way, it is hoped to be able to associate short-term memory and the visuospatial ability, in addition to facilitating and expediting the culmination of the exercise.

Afterwards, the navigation was visualized, beginning the communication of the program with the Bluetooth device, reading the tilt and the force of grip before the beginning of the questions, to obtain a standard of both variables. Their function was serve as reference to compare with the next readings, especially for the tilt and definition of turns made by the hand of the user with the device.

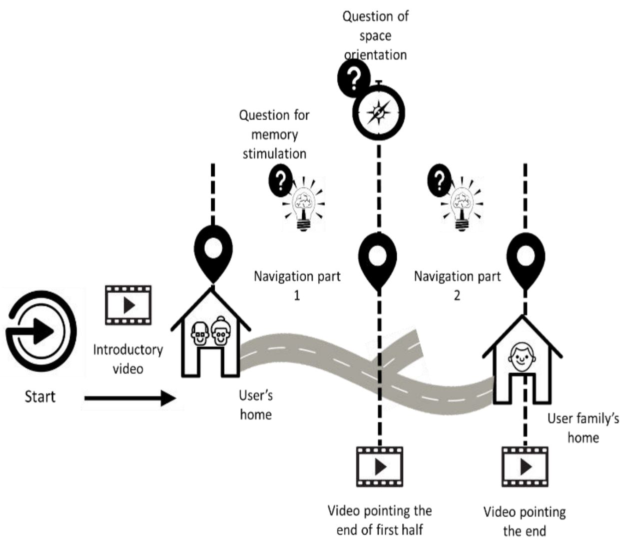

Figure-4. General model of the program.

The designed route must be divided into minimum 2 parts and maximum 5 parts. (Figure-5) The video selection was performed with a cycle case, with "q" as a counter variable, "q" ranges from 1 to 5, each integer in that range represents a part of displacement that makes up the entire navigation path.

In the manual for the person who will elaborate the KML files, it was instructed that separates the total navigation by the places that serve as reference points for the user. Due to when changing from one place to another, the user must respond correctly if he should go North-South or East-West from the last navigation image. (See Figure-5).

When the person complete all parts of the navigation, the variable "AllRoutes" reaches his maximum, which forces to leave the cycle case and finalize the exercise with the playback of their relatives congratulating their achievement. In order to reinforce the motivation of the user and to repeat the purpose of the exercise, preventing the lack of attention that the user may suffer, a video of their relatives was also reproduced in the middle of the whole exercise. (See Figure-5).

However, to complete each part of the navigation and advance to the next one, it is required that the user answer correctly some questions that make function his short and long term memory (See Figure-5). The logic to progress in these questions can be seen in Figure 7. The feedbacks cited therein, may be of two types. One for stimulating short - term memory and visuospatial orientation, and one of only Short-term memory.

First, the question asked was "what is closer to the goal?" (See Figure-6) for the user choose between 2 images. One of a place that already seen and another one that has not yet been shown.

If the answer was correct, he will continue to the navigation. However, when it was incorrect, it replays the displacement, ensuring that the image on which the question was based was displayed. If the user fails to use short-term memory to respond, it can be achieved using their long-term memory. Because it gives the possibility of simply remembering the place, and was guided by his capacity of the cognitive map, to indicate which of the two places was farther away from home, or which was closer to the goal.

This activity will occur on the third part of the scheduled trips, and you can only follow to the next question when you respond correctly. Images that were presented as response options change positions randomly each time the question was asked. Therefore, the advances in the exercise were not achieved if the user tries to guess, remembering the position of images.

In the middle of the all displacement, the other question arises, and this must be answered based entirely on the short-term memory of the patient. Since it was asked "Where do we come from?", Comparing between an image of the previous starting point and an image that was foreign to navigation. The image that the user must recognize was the place where the previous question culminated.

If the user made a mistake in the current question, he will see the navigation from the third part of the displacement, where was asked the previous question, without having to answer it again. Even the question "Where do we come from?" have to be answered correctly, in order to continue to move smoothly until you complete it and continue with another.

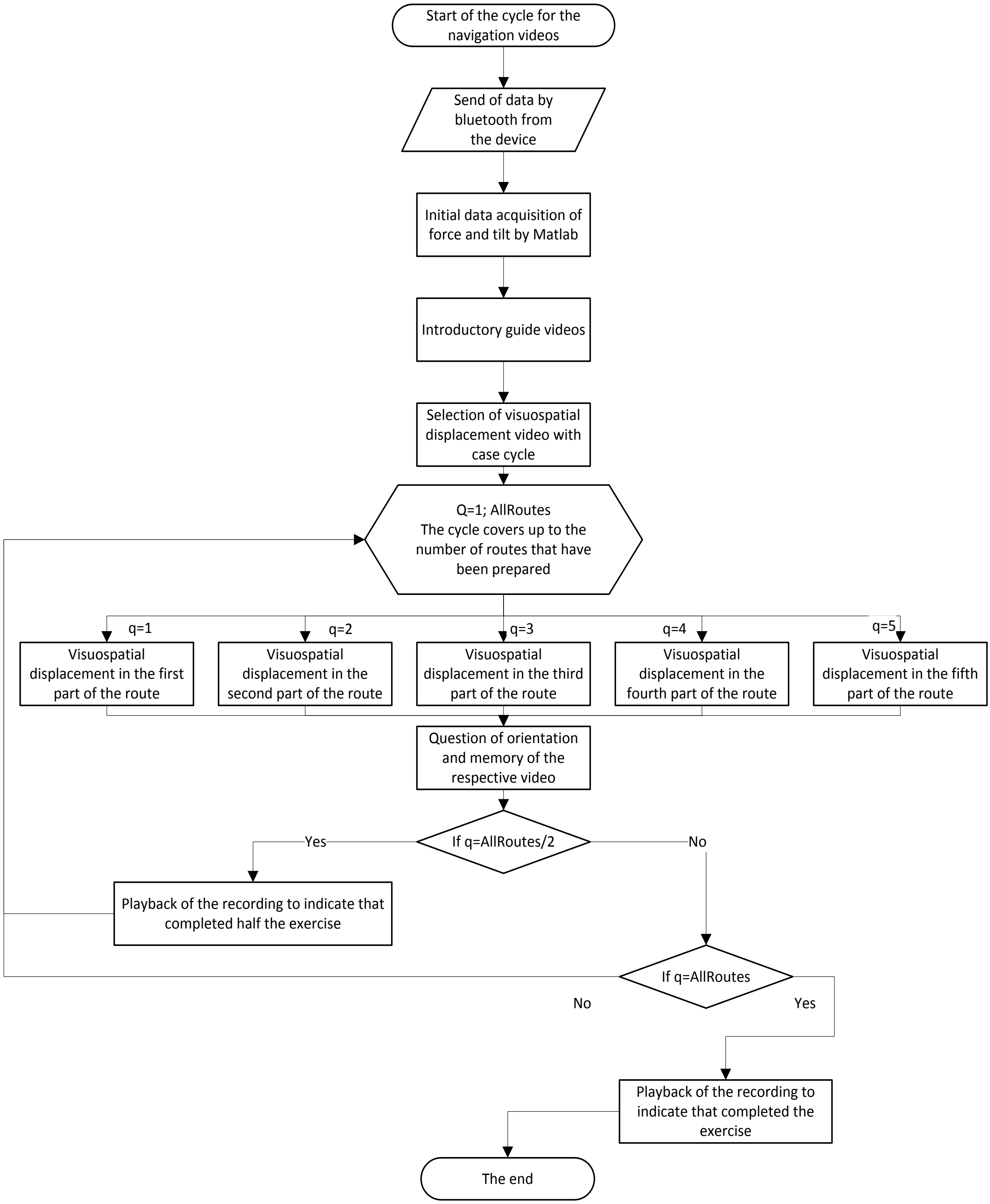

Figure-5. Logic for browsing video selection.

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Figure-6. Stimulation of memory with questions about the visualized images.

In the navigation, the patient continues until it reaches the end of it, but, the patient must answer correctly if he will advance to the North-South or East-West, from the last site presented (See Figure-7). If the user answers incorrectly, he will navigate the portion that just move. In other words, he must repeat the 2 memory questions again. Otherwise he will continue to advance and will face the 2 questions of memory with different content. This will continue until the total number of available partitions of the total navigation will be completed (defined as "AllRoutes" in Figure-5). When covering all the navigation, the program will reproduce a video of the loved ones of the patient to congratulate that the exercise has finished.

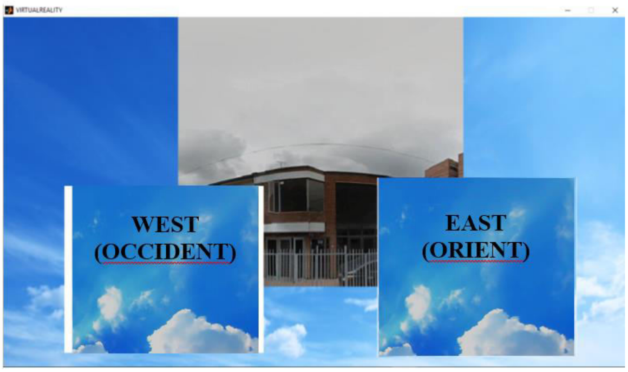

Figure-7. Stimulation of visuospatial ability.

In summary, if there were 5 divisions in total in the visuospatial navigation, there will be 10 different memory questions and 4 visuospatial guidance questions. This can be changed anytime, duet to the connectivity between the program and the shared folder in the software OneDrive® where the navigation files and recordings were stored.

At the beginning and at the end of the exercise, the grip strength was measured without warning the user. Then generate a notepad file on the average initial, final and differential force between the two mentioned, from the 300 data. This file will be automatically uploaded to the OneDrive shared folder, where it can be monitored by the patient's relatives at a distance. An outline of this activity was presented in Figure-8.

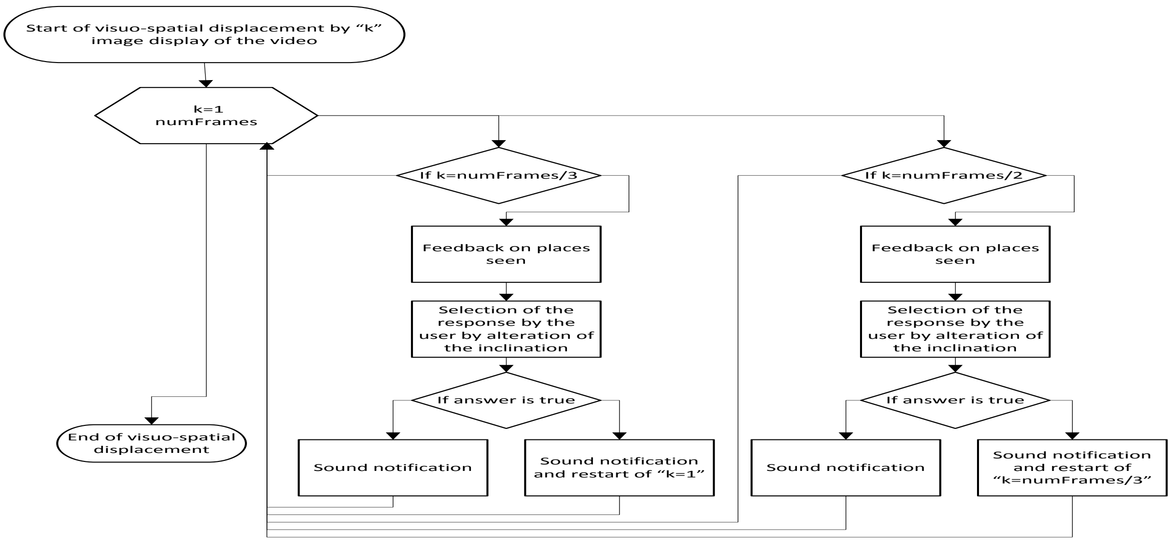

Figure-8. Logic to advance in memory questions.

3. RESULTS ANALYSIS

A test exercise was designed to be used with an 85-year-old female subject without cognitive impairment clinically diagnosed. Visuospatial navigation was carried out with an exercise of displacement in the neighbourhood where she had lived for more than 30 years. The visuospatial route has a length of approximately 900 meters, with a duration of about 4 minutes in the navigation video, which can vary depending on the correctly perform of the exercise.

Visuospatial navigation was distributed in 2 parts, which produced 4 questions to stimulate memory and 1 question to stimulate the spatial orientation ability.

In tests, the user made mistakes as shown in Table-2 and Table-3. In the first test, the subject had support, reading aloud the questions presented. While in the second there was no help to perform the exercise, which was finalized on both occasions.

Table-2. Results of the first test.

First test

Memory stimulating question 1			
Navigation advance	Attempts	Results	Success:Attempts
Part 1	1	×	1:3
	2	×	
	3	✓	
Part 2	1	✓	1:1

Memory stimulating question 2			
Navigation advance	Attempts	Results	Success:Attempts
Part 1	1	✓	1:1
Part 2	1	✓	1:1

Question about space orientation		
Attempts	Result	Success:Attempts
1	✓	1:1

Table-3. Results of the second test.

Second test

Memory stimulating question 1			
Navigation advance	Attempts	Results	Success:Attempts
Part 1	1	✓	2:4
	2	×	
	3	×	
	4	✓	
Part 2	1	×	1:2
	2	✓	

Memory stimulating question 2			
Navigation advance	Attempts	Results	Success:Attempts
Part 1	1	×	2:3
	2	✓	
	3	✓	
Part 2	1	✓	1:1

Question about space orientation		
Attempts	Results	Success:Attempts
1	×	1:2
2	✓	

According to the low number of hits on the attempts that the subject obtained in memory question 1, a failure can be suspected in memory question 1, due to in the second navigation part, when presenting the same type of question, she again commits the same mistake.

As for the orientation question, there were not notable complications. Due to the unique mistake was due to a distraction of her and not answer.

As for the overall handling of the device there was no problem and the subject was able to handle it right away.

4. CONCLUSIONS

A difference between the first test and the second test was highlighted, where there was not assisting in the reading of the questions to the user, the number of hits decreases.

The question "which is closer to the goal?" Seems to confuse the user so the question could be changed or add more time, in order to the user could respond calmly. While the activity was executed an average time of 20 seconds could be measured for each question, before selecting an option. So, it could be increase it at this time. However, there are to consider that this time varies per user. So, it is better change the logic of programming in this segment so that it does not designate a time, but wait for it to have an answer. Although it had been considered not to do in the beginning, due to this requires that the user rotate the device to a minimum or maximum mandatory angle and this can be an obstacle for some elderly who suffer joint pain.

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