The Use of Smart Tools for Combined Training of People with MCI: A Case Report

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Abstract Dementia and Alzheimer's Disease affects more than 35 million people worldwide. The onset and the development of this pathological condition are generally subtle and progressively. Nevertheless, is often possible identifying some precursors symptoms of the disease. A nosographic entity, which describes this condition between healthy and pathological aging, is called Mild Cognitive Impairment (MCI). Over the last years, several new technologies are entering in the field of medicine and neuropsychology, especially, Information and Communication Technologies (ICT). Today ICT are more and more being recognized as a valid instrument for assessment, treatment, and assistance of subjects who are suffering from MCI. This paper reports two case studies about the use of two new technological tools for the cognitive assessment and stimulation of elderly healthy people or subjects suffering from MCI. This study purpose is to investigate the peculiarities, in terms of cognitive performances, highlighted by the use of these smart systems, namely SmartWalk and SmartTapestry system.

Keywords Neuropsychological assessment · Cognitive stimulation · Mild cognitive impairment · Information and communication technology

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1 Introduction

Over the last years, we witnessed the massive increment of elderly people suffering from neurodegenerative diseases, such as Alzheimer's disease (AD). The World Alzheimers Reports have revealed that, in the last few years, the global cost associated with AD increased by approximately +34%, and will reach $ 1 trillion within the next 3 years [1]. The ADs impact is enormous, economically and socially. Indeed, it represents one of the most remarkable causes of disability in older age [13] and, moreover, to date there is no pharmacological treatments able to arrest the disease [1].

Several studies on patients suffering from Mild Cognitive Impairment (MCI), a condition which is deemed a harbinger of dementia [17], have demonstrated that cognitive training (CT) has a healthy effect on various cognitive functions, including attention and memory, but also mood and psychological well-being [19]. Also, aerobic and non-aerobic exercises have been recently used in the treatment of people with MCI. The exercise, in fact, seems to have a positive impact on the cognitive and emotional sphere [1].

Over the last years, new technologies, especially Information and Communication Technologies (ICT), are entered, more and more, in the field of neuropsychological treatment for dementia [5, 7]. This paper describes the use of two ICT smart tools, namely SmartWalk and SmartTapestry, developed as instruments for the neuropsychological assessment and the training of elderly people and subjects with MCI. These tools were minded to combine cognitive tasks with physical exercise, so to exploit the virtuous circle defined by the mutual effect of cognitive stimulation on physical performance [20], and vice versa, the beneficial effect of exercise on cognitive performances [12].

Here are displayed two case studies, with the purpose to highlight the subjects' cognitive performances and process detectable during the use of two alternative smart systems. This study aims to investigating in details how a healthy subject and an MCI subject perform with the two system and which supports and which difficulties they meet in their use.

2 Related Works

The interest in investigating how ICT can be used to tackle dementia is growing faster. Researchers and clinicians believe that thanks to the combination of technological and clinical progress, it will be easier identifying subjects with MCI in a more accurate way [8]. For example, concerning the assessment of MCI patient, several types of ICTs are already available. In their systematic review, Garcia-Casal et al. [8], state that nowadays there are four categories of ICT instruments for cognitive impairments early detection and assessment, such as (i) personal devices; (ii) internet-based devices; (iii) monitoring devices; (iv) virtual reality. They summarize that PC is the most common ICT used in this field and its applications are widely diffuse to assess several neurocognitive functions, among which memory and attention. In addition, in another review emerges that computer-based test could help the clinician in several ways, such as more severe control of assessment condition, which leads to greater psychometric reliability; quick and easy recording of latency and response types; reduce the examiners' subjectivity effect and enable automatic performance correction [5]. ICTs could also be utilized to assess behavioral changes in affective disorders due to MCI, as reviewed in [9].

With regards to ICT for cognitive intervention, Cognitive Training (CT) protocols were implemented with ICT to stimulate the subject intensively, ecologically, economically and in a customizable fashion. Cognitive training (CT) is defined as "*guided practice on a set of standard tasks designed to reflect particular cognitive functions*" [2]. Usually, such tasks are administered by paper and pencil protocols or, recently, by computerized tools [11]. Charchat-Fichman et al. reviewed the literature concerning cognitive rehabilitation and ICT. The authors affirm that new technologies applied to neuropsychological rehabilitation have facilitated the development of compensatory strategies and real-world simulations, leading to greener training procedures [5].

In a more recent review, drafted by Ballesteros et al. [3], the authors report that ICTs furnish great opportunities to improve or facilitate the implementation of multi-domain interventions in aging. The authors mentioned computerized training as the preferred option in most of the intervention studies. This solution is really useful since the program can automatically adapt to the trainees daily performance. Moreover, through the use of video games, it is possible to train only a target domain or simultaneously several cognitive domains.

A recent Garcia-Betances review tries illustrating the ICT application with MCI subjects. The authors sustain that advanced ICT-based tools, such as virtual and augmented reality technologies, are the most fitting platforms for applying nonpharmacological computerized neurocognitive interventions as a means to assess, maintain or improve cognitive functions. Moreover, the authors assert that a synergic application of multicomponent and multimodal neuro-technological intervention seems to be a promising approach. In fact, the application of ICT to MCI subjects can lead to significant improvement in the treatment of memory, sustained attention, executive ability to make a decision, spatial orientation and time and visual perception [7].

Our work aims to introduce the use of two new smart systems in that framework.

3 Materials and Methods

The two developed smart tools are based on neuropsychological task used for assessment and rehabilitation. In particular, was used the "Batteria Computerizzata di Test per l'Esame dell'Attezione" (TEA)[1] to stimulate the auditory sustained attention.

[1] Italian version of TAP "Test battery for attention performance."

TEA is a computerized technique composed by various subtests able to assess different aspects of the attentional domain including sustained attention. Particularly, the task took into account is composed of a sequence of alternated high and low tone. The subject had to detect each irregularity which occurs in the sequence pushing a button, while he is sitting in front of a computer. The output measures that neuropsychology uses to assess the users' performance are related to three main scores: (i) Correct answers, which is defined as the number of changes in the audio track correctly identified. (ii) Omitted answers, which is defined as the number of changes in the audio track not identified. (iii) Error, which is defined as the number of changes identified in absence of changes in the audio track. Other parameters are related to the reaction time of the correct answer, and it includes the mean and the standard deviation (SD) [21].

The SmartWalk system is the TEA litmus test, but its novelty is that it was designed to require a commitment to the subject both on motor side (walking, and mobility of lower limb articulation movement) and cognitive side (attention in relation to the reference standardized test) [6].

The other neurocognitive ability took into account was verbal episodic memory. The cognitive exercise chosen for the stimulation of this cognitive domain was the subtest Verbal Paired Associated (VPA) Learning Task of Wechsler Memory Scale-Fourth Edition WMS-IV, in double condition: immediate (VPA immediate recall subtest) and delayed recall (VPA delayed recall and VPA recognition subtests) [10]. In particular the immediate recall subtest measures the immediate verbal memory of the associated word pairs. 14 or 10 word pairs are read to the subject (the WMS-IV provides an adult version and one for the elderly aged 65 and older, respectively). Later the examiner reads the first word of each pair and asks the subject to recall the associated word. In the subtest there are four versions of the same list of word pairs presented in a different order. The examiner will read these 4 versions and every time, after presenting each list, proceed to the recall (from here reported as Imm1, Imm2, Imm3, and Imm4). The raw score is the sum of the correct answers to the four versions. The delayed recall subtest, indeed, is administered 20–30 min after the subtest Immediate recall condition. The deferred condition evaluates the long-term memory for word pairs. The raw score is the sum of the correct answers. Finally the recognition subtest is a list of word pairs is read to the subject and asked to identify each pair as one of those already present in the previous subtest or as a new couple. The raw score is the sum of the correct answers.

The ICT counterpart developed to stimulate verbal episodic memory by using verbal pair associated is SmartTapestry. Similarly to SmartWalk System, the novelty of this tool is that it was designed to require a commitment to the subject both on the cognitive (memory in relation to the reference standardized tests) and on the motor side (upper limb articulation movement). Specifically, the subject placed standing in front of the system will have to raise the upper limb to perform the exercise. This task involves flexion and rotation (internal and external) movements on the frontal plane. If the subject is placed as to have the side system, he can carry out the same exercise by performing abduction and rotation (external and internal) movements on the sagittal plane [14].

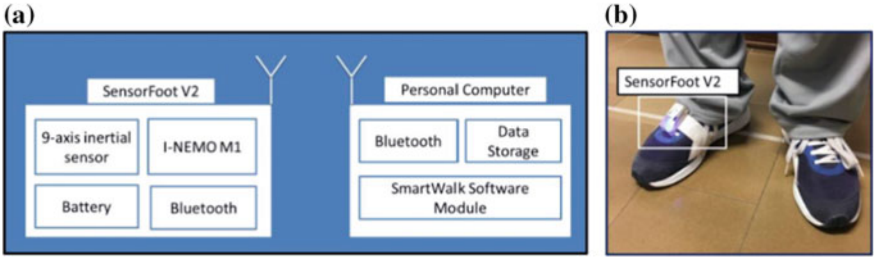

Fig. 1 **a** SmartWalk tool main components. **b** SensorFoot V2 mounted on the users dominant foot [6]

SmartWalk

SmartWalk system is composed of a wearable inertial sensor placed on the dominant foot (SensorFootV2) and a software which collect the data (see Fig. 1). SensorFoot V2 (see Fig. 1a) is able to collect a 9-axis inertial system (3-axis accelerometer, a 3-axis gyroscope, and a 3-axis magnetometer) at a frequency of 100 Hz. The data is filtered on-board with a fourth-order low-pass digital Butterworth filter with a 5 Hz cut-off frequency. The core of this device is represented by the iNEMO-M1 system on board (STMicroelectronics, Italy) with a Cortex-M3 family microcontroller [18]. SensorFoot V2 has a small battery that supplies the system. Data are collected and transmitted via Bluetooth protocol to the software module installed on a computer. The software module is developed with Visual Studio 2013 (c# language) and it is able (i) to collect and store SensorFoot V2 data, (ii) to autonomously administrate the exercise and (iii) to reproduce the audio track for testing the sustained attention (the same of TEA subtest).

SmartTapestry

SmartTapestry is a sensorized tapestry, designed and developed to be used in a combined rehabilitative protocol involving both motor and cognitive functions, as described in [14]. More specifically, SmartTapestry allows the administration of standardized psychometric tests with modalities that are alternative respect to the traditional approach. In particular, since the useful movement for the shoulder is over the 90 line, more frequent letters were placed in that area. On the basis of clinical requirements provided by the psychologists, SmartTapestry was designed with the following elements:

1. A sensitive base (60 × 90 cm) containing: (i) 24 sensitive elements (15 × 15 cm each one) arranged to create a 4 × 6 matrix. Each sensitive element was obtained with a double sheet of conductive textile (Adhesive Conductive Fabric—ACF by Mindsets Ltd.) divided by a 1.5 cm thick foam layer. In correspondence with each unit, holes were performed into the foam for allowing the contact of the two fabric layers to detect touch by the user (the sensing units work like on–off switches); (ii) electronic hardware for data acquisition (Multifunction DAQ System NI USB-6218 by National Instruments), connected to the fabric patches with conductive threads sewn in the foam, and a USB connection to the laptop;

2. interchangeable layers to be placed above the sensitive base with velcro hooks, containing the various targets of the exercises. For instance, in this study the 21 letters of the Italian alphabet were arranged to cover the sensitive units: the system actually works like a wide keyboard;
3. a laptop with a custom LabVIEW graphic user interface to select the desired exercise (tests are administrated through the software) and acquire data from the tapestry (sequence of correct answers and total test score);
4. a mobile support structure for the tapestry, able to adjust the height according to the subject's requirements.

3.1 Protocol

The subjects involved in this study were asked to perform 4 tests, administrated randomly; the traditional neuropsychological task and the equivalent exercise with the smart tools.

At the beginning of the experimental session, written informed consent was obtained from the participants. Study design and protocol, including subject privacy and sensitive data treatment, were approved by the Ethics Committee of the Scuola Superiore SantAnna, Pisa. All methods included in the protocol were carried out in accordance with the guidelines laid down in the Declaration of Helsinki. For further details check [6, 14].

SmartWalk During the traditional test, a neuropsychologist administered the exercise as required by the traditional protocol. Whereas, during the SmartWalk test, firstly the participant was asked to wear the SmartFoot on the dominant foot (see Fig. 1b). As soon as they was ready, they pressed start on the software module thus the instructions were autonomously administrated by SmartWalk software. If they did not understand properly they can listen again the guidelines. Each test lasted about 30 min and was supervised by psychologists and engineers who were ready to intervene in case of necessity. The user was asked to walk at its own natural velocity for the entire test. The acquired data were stored in a computer to be off-line analyzed.

As regards the traditional test, in this study we reproduced a parallel version of the TEA subtest: as soon as the user detected an irregularity in the auditory sequence, they had to click the mouse.

SmartTapestry Each task session took about 1 h, and was supervised by psychologists and engineers in a laboratory setting. The traditional test (VPA-WMS) is administrated by a psychologist that reads a list of word pairs. Whereas during the SmarTaperstry test the participant was asked to stand in front of the system. As soon as they was ready, they pressed start on the software module thus the instructions were autonomously administered by SmartTapestry software. If they did not understand properly they can listen again the guidelines. The instructions and the list of word pairs are provided by the software, while the subject has to type the remembered word by touching letters displayed on the tapestry (See Fig. 2). The data were acquired and stored by a computer.

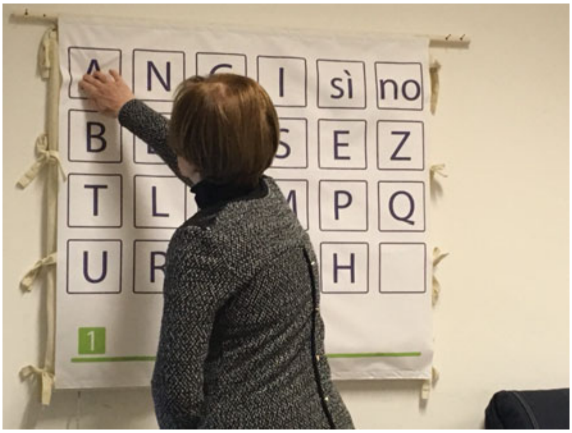

Fig. 2 Participant while performing SmartTapestry test [14]

3.2 Participants

The subjects selected for the case report belong to two different group of participant, one clinic and the other of control, from two feasibility studies about smart tools for assessment and cognitive training of subjects suffer MCI [6, 14]. It was decided to select one healthy elderly subject and a subjects whom is suffering from MCI. MCI diagnosis was carry out by Petersen criteria [17] and deemed to be fit to take part in the study by a neurologist and a neuropsychologist.

The Petersen criteria: (i) subjects who suffer from a cognitive impairment not normal for age; (ii) they are not demented; (iii) whose change in cognition does not cause a significant impairment in functional activities.

Moreover, were verified other further inclusion criteria for the study: (i) ability to walk at normal speed for 30 min without any help; (ii) right foot dominance; (iii) absence of hearing loss; (iv) absence of depression and other psychopathological issues; (v) absence of other neuromotor impairment.

In the two following boxes are reported information about the two chosen subjects. In the case of the subject suffering from MCI also a short medical report was presented.

Anamnesis D. P.

The participant D. P. is a 63 year-old Caucasian woman. She attended 8 years of school and had reported to the experimenter to be in full neuropsychological and medical health.

The subject reported to never have experience of psychiatric disorders, such as mood alterations or anxiety. Moreover, the subject does not believe to forget things or to go towards changing in her way to think.

The subject is oriented, aware, collaborate, and with full insight.

Considered all the aspects listed above, it was decided to consider the subject D. P. as the control subject.

Anamnesis M. R.

The participant M. R. is a 70 year-old Caucasian woman with a diagnosis of MCI. She had several cognitive and behavioral limitation based on neuropsychological assessment, neurological examination and instrumental exams (TC and echo-Doppler).

Mrs. M. R. reported that since a couple of years is suffering from forgetfulness episodes recognized by the clinician as an index of episodic anterial-grade memory issues. These problems began in a subtle manner and got worse over time. In fact, she referred that 1 year after the memory impairment begins she had experienced an episode of topographic disorientation, coming back home from the dentist. In the meanwhile, it started also absent-minded episode, a forgetfulness and/or inattentive behavior, such as forget where she parked the car or left the house key.

In the last 3–4 months the memory problems are getting worse and for this reason, the subject decided to turn to a neurologist. Moreover, simultaneously with the memory deterioration, M. R. started to show some behavioral changes, such as initial insomnia, negative thoughts, irritability, mild agitation and amotivational syndrome, a condition characterized by apathy, abulia anhedonia. In relation to these symptoms, the subject was treated for two months with Zoloft, Samyr, and Illumina, prescribed by the neurologist. As result of an interview about her relatives was been reported that in her father's family branch there were been two cases of Alzheimer's disease. In general, there were not referred cases of mood disorder or depression among family members.

The neurologist assessment and the instrumental exams reported a couple of newsworthy parameters: an enlargement of apical liquor system and a carotid siphons calcification. A complete neuropsychological assessment was prescribed to avoid misdiagnosis, between MCI and depression, and clarify the case.

During the neuropsychological assessment the subject appears vigilant, collaborative and with full insight. The assessment consisted of a comprehensive battery of neuropsychological tests, such as Milan Overall Dementia Assessment (MODA); Wechsler Memory Scale IV (WMS-IV); prospective memory task of Rivermead Behavioural Memory Test (RBMT); Attentional Matrix; Stroop Test; Trail Making Test A and B; Boston Naming Test (BNT); Street Test; Birmingham Object Recognition Battery; Brixton Test; Tower of London Test; Verbal Judgments Test.

Based on the performance shown throughout the neuropsychological assessment was expressed the following clinical opinion: the subject manifested a global cognitive functioning placeable at inferior limit of normality. The study of Memory domain depict a weakening of visuospatial information treatment in all the dimension (short-term, long-term, working memory), but the global performance deposes against a true amnesia. The examination of attentional skills describes a selective impairment on dual task, in part attributable to an increased share of anxiety. The deep study of executive functioning displays an inefficient planning skill and a weak conceptual elaboration of verbal material. In definitive the neurocognitive profile and the clinical observation are deposing to a diagnosis of MCI instead of Depression.

4 Results

In this section will be reported the result of the two selected subjects on the four aforementioned cognitive tests: TEA, Verbal Paired Associated, SmartWalk system, and SmartTapestry system. Two of this concerning the attention domain (TEA and SmartWalk system), whereas the other two concerning the memory domain (Verbal Pair Associate and SmartTapestry system).

Table 1 reports the results related to attention domain, in particular concerning the sustained axis of attention. Both for TEA, the traditional test, and the SmartWalk system, the novel one, is possible to observe a general tendency of the clinical subject to show worse performances, as compared to the control one. The clinical subject, indeed, exhibit a lower number of correct responses both in TEA and SmartWalk system, whereas presents, systematically higher number of errors and omitted response in both the tests. Furthermore, the clinical subject has the tendency to respond slower and with higher variability as compared to the control subject, even though the differences are in the range of millisecond. In Table 2 are reported the results of the two test used to probe the functioning of memory domain, in particular, the episodic component of long-term memory. For the assessment of this neurocognitive skills are generally used two parallel forms of the test, according to the subject age. People under 65 years old are put through on a test composed of 14 pairs of words to remem-

Table 1 Subjects result to attention tasks

Test results	Clinical subject	Control subject
TEA correct	29	35
TEA errors	31	21
TEA omitted	5	0
TEA response Mean (s)	2.31	2.14
TEA response SD (s)	0.68	0.43
SmartWalk system correct	16	33
SmartWalk system errors	10	1
SmartWalk system omitted	13	1
SmartWalk system response mean (s)	2.25	1.98
SmartWalk system response SD (s)	1.52	0.57

Table 2 Subjects result to memory tasks

Test results	Clinical subject	Control subject
Verbal paired associated Imm1	0	1
Verbal paired associated Imm2	6	5
Verbal Paired associated Imm3	4	6
Verbal paired associated Imm4	6	8
Verbal paired associated delayed	5	5
Verbal paired associated recognition	30	28
SmartTapestry system Imm1	3	4
SmartTapestry system Imm2	6	9
SmartTapestry system Imm3	6	8
SmartTapestry system Imm4	6	8
SmartTapestry system delayed	7	6
SmartTapestry system recognition	27	30

ber. On the other side, people over 65 years old are put through on a test composed of 10 pairs of words to remember. So to may compare the results of the two subjects, a normalization based on the maximum score was done. In this way, all the subjects have a range of possible score from 1 to 10 for the subtest: Imm1, Imm2, Imm3, Imm4 and Delayed. And a range of possible scores from 0 to 30 for the Recognition subtest.

As reported in Table 2, the clinical subjects achieve frequently lower scores as compared to the control subject. Especially using the SmartTapestry system. Moreover, on the contrary compared to the performances related to the attention domain, the results accomplished with the traditional form of the exercise are lower, for the clinical subject, if compared to the results achieved with the smart system. Quite the same of the control subject which seems to take advantage of the smart system procedure, using both the systems.

5 Discussion

In this section, the result obtained by the trial will be debated. The clinical judgment about the performance of the MCI subject itself, regarding, her clinical records, and about the comparison with the control subject, will be made. The scores attained in the tests show some interesting patterns. At first, the control subject seems to be facilitated in both the tasks, attention, and memory, using the smart tools systems. On the other hand, the introduction of new technologies, or even the motor exercise, seems to drain the clinical subject performances. The subjects suffering from MCI, in fact, obtained lower scores using the new technology concerning the attention domain, and essentially the same results using traditional and new approach concerning the memory domain. As just said, the differences between the subjects and a discussion about their results will be held in the following.

SmartWalk and SmartTapestry, introduce a physical activity during the execution of the cognitive task. Particularly, in the first case, using SmartWalk, is required to pay attention to a monotonous auditory stimulus meanwhile the subject walk. In the presence of a specific changing in the stimulus tonality, the subject has to stop his/her walking and do an exercise for the mobilization of the lower limb. On the other hand, using SmartTapestry, it is required to carry out an auditory-verbal memory task using a sensorized tapestry to deliver the response. This tapestry is thought to stimulate the use of upper limbs, in particular, to encourage the shoulder girdle mobilization during this cognitive task. Despite the introduction of this physical tasks, the results of the two different subjects, in the two test typologies, are comparable. In fact, as well as using the traditional forms of the tests, the clinical subject shows lower scores in all the sub-tests, both in attention and memory tasks, as compared to the healthy subject.

Furthermore, the clinical subject shows very different performances in regard to the two typologies of the test. As already said, regarding the use of the SmartWalk system, the clinical subject seems to be challenged by the use of the new approach. This result could be explained by the increasing difficulty to accomplish the dual task for the older adult, and, even more for the older adult suffering from some cognitive impairment, such as MCI. As reported by Brustio and collaborators [4], in fact, the addition of exercise, on cognitive tasks, could improve the cognitive effort required to the subject. A subject suffering from MCI possess lesser cognitive reserve, and this aforementioned depletion could show its effects if is required for the subject to complete dual tasks, such as a cognitive task combined to exercise. The difficulties show on the SmartWalk system, are moreover explained by the documented impairment of the subject in dual-task attention, assessed using Trailing Making Test form A and B, and by a general ipoefficiency in executive function. In fact, is just becoming more clear the correlation between impairment in executive functions and difficulties in walking. In particular, it seems that amnestic MCI, which show executive impairment and loss of neuron in hippocampal and cingulate anterior cortex, exhibit greater difficulties during fast-paced walk [15]. On the other hand, the combination of cognitive tasks and exercises seems to facilitate the healthy subject. In fact, as reported in Table 1, the numbers of errors using SmartWalk decrease from 21 to 1. Furthermore, she reported that using the SmartWalk system, the action to walk helped she to focus her attention on the task. This statement, carried out thanks to an essay giving feedback about the system, reflects the sharp false response reduction in the comparison between performances of the subject on the traditional test and the SmartWalk system.

Looking at the performances using SmartTapestry system it is possible to observe that both, the clinical subject and the healthy subject, show a systematically improving about the majority of the performance using this new approach, as compared to the traditional test for auditory-verbal memory assessment. This could be explained by the multimodal nature of the exercise [18], but also by the mild presence of exercise in the smart system. In fact, the task include verbal information that the subject must remember, but also a visual support, provided by the SmartTapestry, used to emit the response. So the information undergoes to two kinds of treatment, first as verbal information, then as visual information. This multiple treatments of the mnemonic trace could be the reason why, both clinical and control subjects, are facilitated by the use of SmartTapestry system [18]. Another explanation could be attributed to the role of implicit memory. The output channel for the response, using SmartTapestry system, in fact, impose that the subject pushes some part of the tapestry, where letters are printed, so to form the right word. The repetition of this task could recruit neural networks involved in implicit memory. The combined effect of explicit and implicit memory may be an explanation for the improvement of the performance, also for the clinical subject, using SmartTapestry system. Furthermore, it is important to remember that in SmartTapestry task is required less dual-task ability.

The two system, as all new technology, possess also some limits. The main purpose of this study is to sound out how these systems work with subjects with cognitive impairment. The partial results inferable by this previous study suggest that the SmartWalk system represents a more complex system as compared with SmartTapestry system, it seems to require a greater cognitive effort from the subjects respect the other. As observed during the discussion the healthy subject had shown a significant improvement in his performance using the SmartWalk system, particularly referred to numbers of false alarms. It seems that the system helps him to stay more focus on the task. On the other and the system seems to require too much effort to the MCI subject. It is possible to think that SmartWalk system could be more useful with people with a very mild impairment, or even with people that showed an age-related cognitive impairment and that want to train their cognitive abilities. The use of this system could be not optimal for people that have deficit related to executive functions or difficulties with divided attention. That is why the task required is more complex, demand the ability to pay attention, planning the gait and remember how to do when the stimulus change. The rate of task impurity is higher and for this reason, considerations referred to subject's strength and weakness are essential.

By the other side, the SmartTapestry system has proved to be useful also for people with MCI, enhancing the ability to encode, store and retrieval the information provided, at the same time, the possibility to do some exercise.

6 Conclusion

According to [6, 14] the two instruments are capable to properly discern between a healthy subject and a subject suffering from MCI, with regard to sustained attention and episodic verbal memory. Moreover, through their use is possible to combine cognitive tasks with exercise. This possibility represents a crucial point thinking to rehabilitation. In fact, is well known that cognitive training combined with exercise determine a greater effect than just cognitive training itself. The benefit is not related only to cognitive functioning but also with the increase of quality of life and reduction of behavioral abnormalities and psychiatric symptoms.

In regard to our tools, previous works, and this report case, suggest that SmartWalk seems to be useful for people complain attention lacks, but that shows a global endurance in cognitive activities. That system could be appropriate for people with a very mild cognitive impairment or for people going through physiological age-related cognitive decline. Besides the SmartTapestry system, because of a less dual-task activity and a less task impurity presence, seems to be appropriate also for people with a more severe cognitive impairment. Furthermore, the physical demand is less lavish compared to SmartWalk.

Further works will outline condition and patients typologies which could represent the best clinical target. The hints coming from this work persuade us that an evaluation of strength and weakness subjects point will be compulsory so to find the best approach for the right patient.

The development of new technologies for the assessment, and assistance of people suffering from MCI and, more general, neurodegenerative disease, represent a huge field of interesting and advancement. Nowadays the priority in this field is to take into account of the specific necessity of single subject, even more, when the object of intervention is related to cognition, mood and in general with psychological dimension. The point, in fact, is not to develop the smarter technology, but rather use the technology developed in the smarter way.

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