A Multi-Sensory environment for the treatment of dementia affected subjects
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Purpose:
The paper describes the early outcomes of a multi-sensory room project to study non-pharmacological therapeutic protocols to stimulate and maintain residual abilities of dementia affected patients. This includes setting, technological solutions, therapeutic protocols and pilot testing. In a nursing home clinical cases and therapeutic practices have been studied before designing the multi-sensory environment enhanced with ambient intelligence technologies. Aim is to obtain an optimal level of stimulation of dementia affected patients through engagement, active participation and intrinsic motivation in a therapeutic (leisure) activity, and favouring the emergence of personal meanings (memories, interpretations, narratives). The outcome of this pilot includes a blended therapeutic model with controlled stimuli, adapted to the patient’s stage of dementia. Therapeutic significance is discussed, as well as design opportunities for future development.

Dementia is a clinical term to designate an acquired permanent deterioration of neurons with impairment of intellectual faculties in several cognitive domains, from memory loss, to abstract thinking, from language disorders to the failure to recognise objects despite intact sensory function. Dementia commonly implies behavioural and psychological disorders as apathy, indifference, or irritability and aggressiveness. For the slowing down of functional decay in dementia, two major trends can be identified: non-specific and specific protocols of non-pharmacological treatment.

Non-specific protocols
Non-specific protocols are based on the principle ‘use it or lose it’ for patients’ residual abilities. They are carried out through various activities - occupational therapy, music therapy, art therapy, and multi-sensory stimulation. The non-specific therapeutic protocol runs through five phases:

(i) Setting  (ii) Exploration  (iii) Negotiation  (iv) Sharing  (v) Evaluation

- In the setting phase, the therapist configures the room choosing familiar tools to support the activity.
- Once the setting has been configured, the patient is invited to freely explore the environment and to choose, with the help of the therapist, an activity to perform, for instance, to paint flowers.
- Therapist and patient agree (negotiation phase) on the duration and the modalities of the activity.
- At the end there is a discussion about what has been done and, in case of group activity, to share the results of the work with other patients.
- The therapist assesses the intervention (evaluation). The last phase allows the therapist to monitor advances of the patient and to re-define the setting of the next therapeutic session.

Specific protocols
The theoretical foundation of specific therapeutic intervention is cerebral plasticity, the ability of the adult brain to adapt and compensate severe acquired damages. Specific therapeutic protocols are characterized by a precise control of the stimulus targeted to the specific loss and the actual level of neuropsychological decay of the treated subject. This implies a strong structure, and prevents the patient from expressing preferences since the activity consists mainly of the execution of tasks (cognitive intervention).

Specific therapies have received experimental confirmation and they have become trusted techniques to face dementia cognitive decline. These protocols follow four sequential phases:

(i) Setting  (ii) Proposition  (iii) Execution  (iv) Evaluation.

- In the setting phase, the room is configured and the tools selected according to the therapeutic objectives.
- The next phase is activity proposition: the therapist explains the task, showing the usage of the tools if necessary. During this phase the patient is passive and listens to the therapist’s verbal instruction.
- At the end of this phase, the patient undertakes a more active role starting the task execution. The therapist holds the direction of the activity providing instructions for a correct execution of the task and monitoring the activity to dispense a balanced level of stimulation. The patient is mainly an executor of the task no space is left for interpretation and personal involvement.
- The evaluation phase is the same in non-specific and specific protocols.
A new, blended, protocol

Therapeutic multi-sensory intervention aims at non-pharmacological therapeutic protocols. A multi-sensory room has been designed to explore the opportunities of ambient computing for developing innovative multi-sensory environments. Detailed objectives of our project include:

(i) stimulation of patients’ cognitive abilities: addressing memory loss, spatial and temporal disorientation, attention and other dementia related disorders
(ii) contribution to patients’ psycho-behavioural wellness: addressing aggressiveness, hallucinations, delirium, wandering, hyperactivity, depression, mood instability
(iii) reduction of patients’ isolation and stimulation of social interaction and communication exchange
(iv) stimulation of patients’ motor abilities
(v) allowing therapists to design different therapeutic activities according to patients’ specific needs.

In our multi-sensory room a flexible and adaptable therapeutic environment is created that is augmented with flexible and intelligent technologies, allowing the therapists to tailor activities to specific cognitive and behavioural problems of dementia affected patients. In addition the environment provides relaxation, engagement and stimulation without renouncing stimulation control and fine tuning.

Key values of the newly developed protocol are:

(i) stimulation of multiple senses
(ii) dynamic tuning to optimal levels of stimulation
(iii) engaging patients
(iv) supporting intrinsic motivation
(v) emergence of the patient’s personal interpretation
(vi) patient’s active participation.

The room is equipped with ambient technologies and active tools, to create an immersive experience and raise the patient’s interest. The system is designed to be flexible enough to allow the therapist to dynamically modify the configuration of the stimuli in relation to different activities, therapeutic objectives and the patient’s need. The room is a re-configurable system, supporting both specific and non-specific protocols. The new protocol that results is a blended product that preserves patients’ engagement, motivation, participation and elicitation of personal meaning, while allowing control and fine tuning of the stimuli (Figure 1).

Our multi-sensory room allows for a continuous assessment and tuning process, within a single therapeutic session to better suit patient skills, ensuring smooth passages among phases, and avoiding activity breakdowns.

To engage patients in the exploration of objects and their responses we designed simple, but unfamiliar artefacts, pleasurable to manipulate, with different kinds of feedback (visual, audio, tactile). The therapist coordinates the session by defining the protocol, the setting, the most appropriate level of stimuli according to patients’ needs, and also supports the patient in remaining involved in the activity.

The following tasks were chosen:

(i) Colour mix: mixing the red, green and blue (RGB) primary colours of stacked LSUs
(ii) Sequence match: enumerating the LSUs with the application ‘checking the correct increasing or decreasing order with sound feedback
(iii) Free dialogic use of the RPs: automatically summing the number of movements with a gradual colour change from green (little movement) over different colours to red (much movement), emitting harmonic sounds from low tones (little movement) to higher tones (much movement), and vibrating at maximum input. The trials were video recorded, and after each session the therapist was interviewed.
**Avoiding negotiation**

Lady CA entered the nursing home a few years ago with a diagnosis of severe dementia, now rated 10 MMSE. She is usually quite active and available to be involved in new activities. However, even if she is quite curious about any novelty, she presents difficulties in maintaining focused attention on a task. She shows logorrhea and when involved in a discussion she correctly respects the conversation turns, but her talk is mostly unrelated to the discourse. The objective of treatment was to stimulate her residual capabilities, to attract and maintain her attention during a task, and to work on her short term memory. One of the residual cognitive abilities she correctly exhibits is mathematical reasoning. She used to work as accountant and seems still to be at ease in manipulating numbers. Based on these considerations, the therapist selected the sequence task with numbers, and the following steps of the blended model: exploration, proposition, execution, and sharing.

He avoided the negotiation phase because of the problems the lady has in catching the context of a discourse, in particular before starting a concrete activity. At the beginning of the session, the therapist configured the environment, setting the LSUs to the sequence task with numbers. They explored the tools together but when the therapist realised that the presence of different stimuli related to sound, colours and numbers distracted the lady, he decided to disregard the sound and concentrate on the visual stimulation. After the exploration the lady looked relaxed and demonstrated to have acquired a certain familiarity with the tools (piling, moving, waiting for feedback). The sequence task was executed without any particular difficulty and at the end of the session the therapist invited the lady to share the experience with him. She reported a general sense of pleasure, and even after a while, when she could not explain what she had just done, she said to be happy and to look forward to spending time in the multi-sensory room again.

During the interview at the end of the session, the therapist said he was satisfied with the flexibility of the environment, and in particular with the opportunity to tune the stimulation before the execution of the task. The specific setting composed of a dark and silent environment with the coloured lights of the tools allowed the lady to be more focused on the task and to reduce unrelated talk. Even though the numbers attracted the lady more than the changing lights, the manipulation of the tools engaged the lady and the repetitiveness of the task and the constant feedback encouraged her to go on.

**Exploration, negotiation and sharing**

Lady SC entered the nursing home with a diagnosis of severe dementia, currently rated 11 MMSE. She is hyperactive and logorrheic showing frequent rummage. She does not focus attention and her short term memory is seriously damaged. The objective of the treatment in the multi-sensory room was to relax, to stimulate sensory-motor coordination with objects through imitation of patterns (this to reduce apathetic manipulation typical of rummage), and to convey her physical activity on a task she can consciously reflect upon.

The therapist selected for her the free dialogic use of RPs, and the following steps of the blended model: exploration, negotiation and sharing. The therapist configured the lighting of the environment in a dark nuance and invited the lady to explore the tools. Three basic patterns were proposed: rolling the pin on the table, shaking the pin and rolling it through the hands. At the beginning of the session the therapist explored the tools together with the lady, pretending to share the lady’s surprise to the behaviour of the tools. After the exploration, the therapist started to roll the pin on the table without explicitly asking the lady to imitate his actions. After a while, the lady started to imitate the movement pattern (for instance, rolling the pin on the table slowly), and in response to the sound and light feedback, she tried to reproduce also the pace of the movement to obtain the same feedback the therapist had on his pin. The activity went on for ten minutes without pauses. The lady was mainly silent during the activity (an unusual behaviour for her who likes to talk continuously and attract attention) just saying from time to time “Can we continue?” In the sharing phase she could not really verbalise the experience but she held the pin in her hand without any rummage.

In the interview, the therapist commented that the use of the RPs was extremely engaging also for him. The lady accelerated the movements in response to his implicit invitation and the obtained feedback acquired after a while a perfect synchronisation. The RPs seemed to be effective in training the lady to perform structured sensory-motor patterns, but they failed in raising an interpretative endeavour in the lady.
**The complete blended model**

Lady CO entered the nursing home with a diagnosis of mild dementia rated at present 24 MMSE. Her main problem is a profound depression getting her to isolate and to avoid public spaces and social events. She will not smile and her talk is always related to dramatic events like her husband's death.

The objective of the treatment in the multi-sensory room is to involve her in social activities, to attract her attention, to stimulate her to assume positive expressions like smiling and to maintain her short-term memory. Earlier the therapist had worked with her on these three tasks, and now decided to follow all the steps of the blended model since the lady's cognitive and sensory-motor capabilities are still good. The therapist set the environment choosing a dark ambient lighting but since the lady reported a sense of panic for the small and dark space, he adjusted a bit the light and reassured the lady with his presence in the room. The exploration was an extremely successful activity. Even if the lady was a bit scared in touching the tools, after a while she got enthusiastic about their behaviours. She perfectly understood the functioning of the LSUs and the RPs, recognising them as sophisticated technological tools. She appreciated so much their behaviour to produce expressions like “If I had died yesterday I could not have seen such wonderful things”. She was able to control the tools very easily and verbalised her intention to try new configurations: “If I put this cylinder on top of the others, they will become grey”.

The negotiation was easily performed. After having tried out the tools, she proposed the sequence task of piling the cylinders from the one with the biggest square to the one with the smallest. During the execution of the tasks with the different tools, she smiled a lot and she paid attention to many cues that the other subjects did not notice. For example, she reflected on the tactile stimulus produced from the vibration of the pins, saying that she would never touch the pin if she was alone in the room. Both the sequence and colour tasks were successfully performed, and she reported the rewarding effect of performing a task correctly. Many times she said “I believed to be foolish but this should not be true if I can solve the task so easily, even the first time”.

During the interview, the therapist reported that the experience was very positive. Even if the environment was initially a little scary for her, it was sufficient to slightly change the setting and to involve her in the exploration to overcome the initial embarrassment.

**Discussion and conclusions**

In care institutions elderly people are away from their familiar contexts and have lost points of reference both in their physical and in their affective space. A careful design of the therapeutic context is essential to put the subjects at ease and to provide them with stimuli to bring leisure and perform tasks to train their residual abilities. From a therapeutic point of view, a dynamic, flexible environment is the key factor for obtaining an optimal stimulation tailored to the specific needs of each patient. Despite the pilot nature of this preliminary study, results are encouraging. Cutting edge technologies supported non-pharmacological therapy in our three cases of institutionalized older women with dementia symptoms.

As said above, the trials in the multi-sensory room are at the initial stage. Therapists have to be trained in configuring and controlling the room and in selecting an optimal path within the blended model. Next steps in multi-sensory design will be to complete the implementation of the tools to include ambient feedback and to try different configurations of the tools and the environment, for example, associating a smell feedback to the tools, or covering the tools with different tissues and materials to enrich the tactile stimulation. Future tests will be enriched with quantitative measurements. We plan to measure severity of dementia, number and type of errors, and duration of the task execution. Furthermore, we are designing an environment that includes pre-test and post-test questionnaires to have comparative data on the impact of the treatment.