Cerebrum – Virtual Cognitive Rehabilitation: a Modern Therapy Tool Focused on Recovering from the Disorders Affecting the Cognitive Performance of Deployed Soldier

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ABSTRACT

Stress has its origins in an exchange between the individual and his surrounding environment and how the first one reacts to the stimuli of the second one. The loss of balance between environmental solicitations and the ability to cope with them generates non-adaptive responses that threaten resilience and can compromise the maintenance of mental health.

In normal physiological conditions, an acute stressful stimulus triggers the mechanisms that lead to the release of cortisol, commonly known as the "stress hormone". In appropriate conditions and adequate concentrations, this hormone is functional and protective for the individual and becomes central to let somebody face alert or danger situations. It also plays a crucial physiological role in modulating the neurochemical mechanisms associated with neuron tropism and more generally with neuronal plasticity. If cortisol levels are too high and its release lasts too long, the effects can be cognitively deleterious.

Military personnel employed in service and during missions are exposed to critical events whose psycho-emotional value correlates them with traumatic etiopathogenesis. The effect of the trauma breaks into the subject's activities, reducing the efficiency and effectiveness of adaptive strategies.

In the military field, particular attention has always been payed to techniques to improve the psychological resilience of personnel. In fact, dedicated guidelines and effective prevention and training programs (pre and post deployment) have been developed in order to help military personnel in managing stress. As an example, think about the techniques of Stress Inoculation Training and Resilience Training, that are part of the Stress Management Training program.

In order to make these techniques more effective, the Virtual Reality "VR" technology is widely use, which offers a multisensory representation of the signals in a highly interactive, ecologically valid and emotionally engaging ambience.

Thanks to the immersivity of VR in the pre-deployment, people are guided to act in stressful situations throughout a gradual multistep desensitization technique. This allows to learn in advance the processes necessary to master reality on an emotional-physiological, behavioral and procedural level.

During post-deployment phase, if traumatic events or situations of hight stress have negatively affected superior cognitive abilities, the recovery of these functions becomes essential.

An example of virtual technology created for this purpose is Cerebrum - Virtual Cognitive Rehabilitation, a VR system split into three modules, one for each cognitive domain.

It is an add-on tool to the various therapeutic paths, capable to combine innovation and attractiveness and able to reduce the perception of stigma both by personnel operating in a purely military context as well as by the so called "digital generation".

The results of the various research conducted on VR highlight immersivity as the main feature. The researches carried out on Cerebrum using a sample of 39 people confirms this feature. In fact, the individuals subjected to the test presented the same emotional involvement and psycho-physical activation as the subjects exposed to the real context. Consequently, the benefit of using this technology within the entire military operative cycle to treat disorders that interfere with cognitive performance can be easily deduced.

Keywords: stress, virtual reality, military, Cerebrum.

INTRODUCTION

Hans Selye defined stress as a "General Adaptation Syndrome", that is to say "a response our organism implements when it suffers the prolonged effects of various kinds of stressors, such as physical (as is the case with fatigue), mental (for example, work-related effort), social or environment-related stimuli (e.g., obligations or requests arising from the social media)" [1]. Stressors may trigger non-adaptive responses which threaten resilience and may jeopardize the mental health of any given subject in the long run, whenever they produce an imbalance between environmental stress and the capacity the subjects have to cope with it. The adaptation process is a complex activity, which takes not only problem solving, but also the subjects' emotional response triggered by events into account.

Individuals are under the constant challenge to maintain an optimal cognitive performance nowadays. Such an aspect concerns complex working environments in particular, as the individuals working there must cope with a significant mental workload within particularly stress-intensive situations.

By its very nature, the military context is an environment where individuals are constantly stimulated, sometimes because of the inner workings of their jobs and some other times because of the specific role connected with their profession.

Some studies have shown how stress can impair cognitive efficiency, also in the absence of visible impacts on task-related performance [2]. Within some situations, performance may be ensured by compensatory effort, to the detriment of cognitive costs, therefore entailing consumption of resources and a loss of efficiency.

Suffice it to think about the routine of the specific tasks which define military life: hierarchy, the transfers from one installation to another, some of which occur regardless of the will of the interested party, while others, even in the case they are intentional, they require an effort to juxtapose professional growth and personal and family needs, the health and hygiene conditions, the uncertainty about the returning date from missions and the lack of privacy. Such processes call for continuous adaptation, with an expenditure of resources and that may silently usher in problems for servicepersons within one or more cognitive domains.

Furthermore, stress can affect cognitive abilities, either helping or impairing performance; in the former case, performance can improve whenever individuals are exposed to moderate stress levels, as they are kept aware and careful.

Starting with this observation, we may infer that somebody their operations may benefit from the presence of moderate stress factors and be impaired by the presence of situations featuring low stress levels, such as boredom, in order to achieve successful performances. On the contrary, exposure to stress, from a high to significant degree and acutely, may jeopardize performance on explicit memory tasks, on decision-making based on practical rules or guidelines, as well as on the capacity of analyzing complicated direction, as well as on managing information, without interfering on implicit memory tasks [3,4].

Remaining in an environment which features threats, the possibility of direct attacks, firefights, loss of troopers, physical stimulations, work overload, sleep deprivation, the temporary disappearance of aspects of the familiar routine, may open up servicepersons to combat-related fatigue. Suffice it to think about "out-of-area operations", during which servicepersons may be affected by several types of social and sentimental distress, up to the exposure of full-fledged traumatic events, whose psychoemotional value may correlate them to traumatic etiopathogenesis. The effect of trauma disrupts the activities of any given subject, reducing the efficiency and effectiveness of adaptive strategies [5] and an effective stress management ensures operational readiness in soldiers, considering also the management of critical situations, which require rapid and automatic reaction times.

1.0 THE EFFECTS OF STRESS ON THE BRAIN

It is well-known that a prolonged stress can increase the risk of developing psychiatric symptoms, such as anxiety and depression disorders, but may also affect awareness.

Cortisol modulates several vital functions at the peripheral level (concerning metabolism, secretion of hormones. cardiac and immune functions) and at the cerebral level has a crucial role in the neurochemical mechanisms connected with trophism and neural plasticity [6,7].

As presented in Fig. 1, when a situation is perceived as stressful, it activates the hypothalamic-pituitary-adrenal axis (HPA) which, by producing the corticotropine release hormone (CRH) and the adrenocorticotropic hormone (ACTH), triggers the secretion of glucocorticoides (corticosterone in animals and cortisol in humans) and catecholamines (adrenaline and noradrenaline) [8].

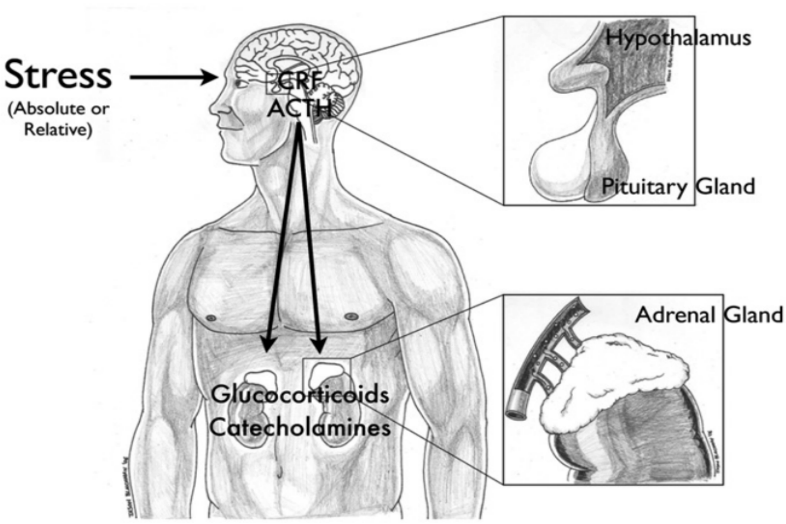

Figure 1: Schematic representation of the hypothalamic-pituitary-adrenal (HPA) axis. Following the perception of a stressor, the hypothalamus releases CRH, which activates the pituitary gland and the leads to secretion di ACTH. The ACTH levels are detected by the adrenal cortex, which then secretes glucocorticoids and catecholamines [8].

The activation of this axis increases the availability of energetic substrata within several body parts, presenting itself as a basic adaptive mechanism as a response to change, however, its prolonged activation is a risk for the health of the body as a whole [8].

Indeed, whenever its concentration is physiological in nature, cortisol has an important function whenever an individual has to face an alert or dangerous situation, favoring wakefulness and increasing both arousal and energy. On the contrary, exposure to intense or chronic stress leads to greater secretions of this hormone and to an excess release of exciting neurotransmitters, itself a mechanism leading to epigenetic modifications within different neuron populations. These phenomena result in a decrease of the plastic properties of the brain, loss of neuronal trophism and an inhibition in neurogenesis [9]. Therefore, the brain becomes more vulnerable to neurodegeneration, with alteration within the cognitive, affective and emotional spheres.

A study by the University of California in Berkeley [10] shown that stress can change the production of oligodendrocytes, while negatively affecting neurogenesis. Therefore, the cellar composition and the structure of white matter, fundamental in the transmission of messages within the brain, are altered.

Other studies proved how stress alters synaptic activities within the prefrontal cortex, causing a deficit within the shifting attention [11], short-term memory [12] and working memory [13,14].

Other researchers have surveyed the possibility of any and all cases of malfunctioning for the frontal lobes, and therefore of executive functions in the presence of strong stress, in particular PTSD.

Concerning such a point, Aupperle et al. [15] summarized the results of studies which concerned executive functions, especially those connected to PTSD. In particular, they focused on the deficits within the inhibition and attention regulation capacities which may precede exposure to traumas, and therefore be a risk factor for the development of PTSD.

As they considered executive functions, the authors focused on the capacity of maintaining and of controlling the complex behaviors directed towards any given specific purpose.

It emerged that the people suffering from PTSD which had some warfare experience, when they were compared with victims without PTSD and control groups without trauma, performed worse in hearing attention and working memory tasks. About sustained attention and inhibiting functions, the studies have shown, time and again, that the persons suffering from PTSD had a reduced performance concerning sustained hearing and watching attention (evaluate with *Continuous performance test*, CPT), featuring a significant number of intrusion errors, themselves a harbinger of inhibitory difficulties. Even when they undertook tests evaluating their inhibition capacity (*Go-no-go tasks, Attention network tasks, and Stroop test*) the performance achieved by people with PTSD was consistently lacking and connected with the gravity of the symptoms.

Some studies on the effects of the exposure to chronic stress have proven that, while a compromised memory may arise from damage to the neurons in the hippocampus [16], the influence stress has on executive functions, such as sustained attention and working memory, comes from alteration within the catecholaminergic system [17]. The latter encompasses the dopaminergic mesofrontal neurons, which originate from the midbrain and project to the prefrontal cortex [17,18,19]. Chronic stress can reduce the activity of these neurons within the substantia nigra and within the tegmental ventral area and impairs dopamine turnover into the terminal regions of the prefrontal cortex, leading to neurocognitive malfunctioning [11,14].

Therefore, chronic stress, according to its type, intensity and duration, determines the specific and complex structural modifications described above by means of a supramaximal secretion of cortisol. Such experimental evidence supports the concept of how important it is, in order to avoid losing neuronal trophism, to succeed in normalizing the brain levels of this hormone. This phenomenon is vital when improving brain plasticity is concerned, together with the neuronal capacity for adaptation and with the need to ensure the best possible performance, during alerts, under stress and when resting.

Considering the aforementioned scientific evidence, chronic stress and, more precisely, trauma, can be both dangerous and damaging within a military context.

Such a point was proven by a specific research conducted by the University of Amsterdam on some NATO soldiers who went back from Afghanistan [20]. Within the study, 33 soldiers which took part in the Isaf (International Security Assistance Force) for 4 months and the relevant data were compared with those of the people belonging to the control group, made up by 26 colleagues which have never been deployed in war zones.

By using brain imaging techniques and neuropsychological evaluation instruments, the researchers have shown how the exposure to chronic stress within any operational theatre produces negative effects on the brain networks checking and regulating attention, executive functions and, specifically, the planning and decision-making procedures; the researchers had also noticed a reduction in midbrain integrity and activity, as well as its functional connection with the prefrontal cortex.

Patrolling activities, firefights and explosions compromise midbrain structural integrity as they interfere with the capacity soldiers have of keeping careful and focused as they carry out complex cognitive activities.

By means of a follow-up study, researchers noticed that, while some of these changes were resolved within a year and a half, the alteration of midbrain connections and the prefrontal cortex proved to be irreversible (Fig. 2).

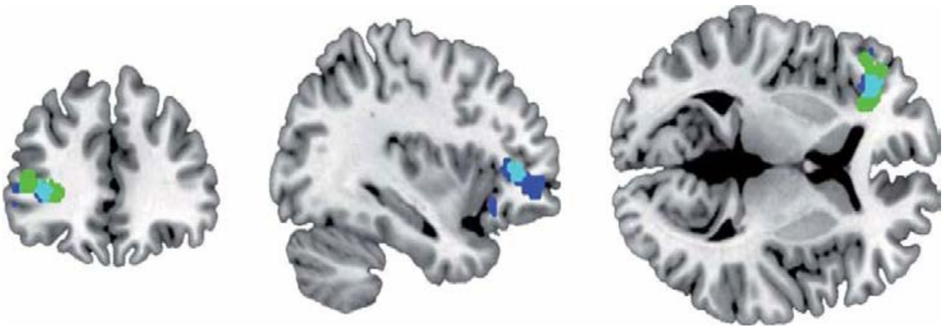

Figure 2: Combat stress reduces midbrain functional connectivity with the lateral prefrontal cortex. The reduction from baseline to short-term follow-up is highlighted in blue. The persistent reduction from baseline to long-term follow-up at 1,5 years after military deployment is presented in green. The overlap between the short-term and long-term effects is presented in cyan. All statistical tests were corrected for multiple comparisons (P <0.05, SVC). The figures are presented at P < 0.005 uncorrected to illustrate the spatial extent of the results (-36, 36, 6) [20].

This results suggest that the human brain, surely thanks to its neuroplastic properties can, by and large, recover from the negative effects of stress in an adaptive and functional way, but they also show that combat stress may leave persistent signs in the brain of soldiers, triggering difficulties for their social and working reintegration.

What should be done in such cases? What can be done if, as he or she returns from any given operational theater, a soldier is affected by a decrease in his or her cognitive skills?

Neuropsychologic rehabilitation is the preferred treatment for such impairments. Through exercises involving cognitive stimulation and enhancement, brain plasticity is increased and the cognitive functions may be rebalanced and returned to a normal level.

1.1 Prevention and training programs for stress management

Soldiers are exposed daily to activities requiring the mobilization of cognitive and emotional factors. Not only stress can interfere with performance, but can also be the source of significant psychological disorders, PTSD amongst them. In recent years, the focus has been shifted towards the programs intending to improve psychological resilience, with the goal of providing soldiers with training tools, themselves able to prevent and/or face combat stress, while increasing coping strategies. Some guidelines and effective training programs do exist and they integrate themselves within the whole of the deployment cycle (pre-during and post deployment) in order to help servicepersons with stress management. Suffice it to think about the *Stress Inoculation Training* (SIT) techniques, as well as the Resilience *Training* (RT), both of which are a part of the *Stress Management Training* (SMT) program. The SMT initiative includes several different approaches, such as relaxing exercises and cognitive coping skills, in order the improve the way people cope with stress [21].

The majority of the resources on the effects of SMT programs focuses on RT, which teaches stress management techniques, and on SIT, which, on the other hand, aims to build tolerance to stress through exposure to it.

As a term, resilience refers to the capacity individuals have to maintain functional balance and show positive adaptation despite the risks to psychological health. It has been shown that resilience training (RT), that is to say learning stress management mechanisms in a non-stressing environment, can minimize subjective stress evaluations, therefore increasing individual [22,23].

By using SIT, individuals can lower the individual physiological response levels, reducing the novelty effect, learn to manage uncertainty and to maintain high performance levels, despite the presence of stressing stimuli [24]. The individuals which learn strategies to maintain their performance while under stress gain a further degree of mastery in their tasks, as well as in their self-esteem [24,25]. What we stated above suggests the importance of focusing attention on training being focused on acquiring specific skills, in order to build up adaptation capacity for soldiers through the realistic representation of the environments they are the protagonists of. We may therefore infer how training, combined with the exposure to stressing factors, may contribute towards improving performance, strengthening problem solving skills and improving coping strategies.

2.0 VIRTUAL REALITY

There are numerous researches that document the value brought by the use of VR to the clinical evaluation and treatment of cognitive and emotional disorders by reproducing ad hoc simulated environments under controlled conditions [26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41].

VR is a technology that consists in the creation of a series of three-dimensional environments where users not only feel like they are physically present but with which they can also interact in real time. Virtual reality is made up by experiential and technological factors; indeed, it is in particular the first aspect, the experiential one, which makes this technology innovative, as it is able to let the subject shift from being an observer to the protagonist of reality. Within any given virtual environment, the perception-related components (be they visual, tactile or kinesthetic) interact with the surrounding world: it is indeed possible to come to know any given object and learn how to use it, based on the direct experience, and in real time, of the reactions to their actions [42].

Up until now, there have been many studies in the field of clinical psychology focused on the application of VR in assessing and repairing attention and memory, both in clinical and non-compromised populations [35,43,44]. Studies have also been published relating to the use of VR as a tool for psychotherapy, based on exposure for the treatment of phobias, post-traumatic stress disorder and anxiety disorder. A great deal of care has been taken in treating such disorders, as they have a higher prevalence rate within the population [45], even if PTSD is harder to treat, compared to the former [25,46].

Virtual reality, within a clinical path, offers patients the opportunity to actively participate in the recognition and awareness of their own thoughts, emotions and behaviors, within specific situations.

Virtual reality can be considered as an adjuvant for exposure-based psychotherapy in the treatment of multiple anxiety disorders [34,47] with the advantage, compared to cognitive-behavioral therapies, of being more effective in the treatment of those subjects with poor imaginative abilities or who refuse *in vivo* exposure [26,48,49]. The sense of presence that is felt, even in the awareness of the simulation, can recreate atmospheres and make the persons involved feel much more vivid emotions than could happen with the simple recourse to memories or imagination [50]. VR presents itself as an evolved imaginative system [51] able to provide an experience connecting the reality recreated by technological supports to the actual one, significantly reducing the distance between reality and imagination with limited economic and psychological costs.

Interventions with virtual environments show numerous innovative features compared to traditional therapeutic protocols. The first aspect concerns the clinical professional who can carry out the assessment together with the patient, building the hierarchy of anxious stimuli within the virtual scenarios, and then planning and carrying out desensitization programs, exposing the subject to stress within protected virtual environments [52,53]. Such a technique can be traced back to cognitive-behavioral flooding, albeit under a technological lens. Furthermore, the virtual environment is built from scratch and therefore it can be made completely flexible, adaptive and interactive in ways that are not feasible, or may be even impossible in the real world. The second aspect concerns the different components of the virtual environment subject to extensive control by the clinical professional so as to allow them to establish, from time to time, what degree of difficulty to present to the patient, in relation to the evaluation of time and progress [54]. The third aspect refers to the performance of activities in virtual environments, allowing the therapists to immediately deal with the disputing on dysfunctional beliefs, more accessible and vivid during the exposure, rather than during a more traditional interview. The fourth aspect is immersiveness, that is, the ability to create in any given subject the feeling that that particular situation is real and that he is really present there. This allows the individuals involved to experience their own effectiveness as well.

2.1 Virtual Reality and the military environment

In the military field, VR is already used effectively in the training of soldiers. During pre-deployment, thanks to the immersion feature, military personnel are guided to act in stressful situations through a gradual desensitization technique. This allows the advanced learning of the processes needed to master reality before facing those same potentially stressful situations live. This process is useful into helping soldiers react correctly without having to deal with any given extreme situation immediately and the gradualness will also allow them to achieve the required goal using all the skills and resources needed. Exposure to virtual scenarios allows soldiers to internalize and consolidate learning processes; therefore, training in a real environment allows the acquisition of useful tools to deal with potential stressful scenarios, managing to maintain adequate levels of performance and maintaining suitable responses at the emotional-physiological, behavioral and procedural level (Technically, they know what to do, as they have already done it during simulations) [55].

Always concerning context of stress management, VR has achieved positive effects with guided meditation by therapists during scenes inducing relaxation responses [56].. As we have already mentioned elsewhere, the realistic reproduction, the involvement and the feeling of immersion allow the soldiers under treatment to have a more vivid experience than they could do through their own imagination [57].

Suffice it to think about the servicepersons under the exposure to war scenarios: VR is able to allow soldiers to experience situations "as if", so that their emotions do not overwhelm them. Therefore, virtual scenarios become a safe base from where soldiers may explore, experience, relive past feelings or thoughts in full freedom. Speaking more generally, persons are inserted within the condition of experimenting that the ideas they have, both of themselves and of the world at large, are not something absolute, but that may be modified.

VR sessions may quite effectively train "to fight", as they can faithfully reproduce war scenarios, slashing both costs and times, without exposing soldiers to real dangers.

Furthermore, VR could be considered more attractive and able to reduce the perception of stigma, both by personnel operating in a purely military context and by the "digital generation".

VR has also been introduced, considering the military context, in the post-deployment for the treatment of post-traumatic stress disorder. The Cognitive Behavioral Therapy (CBT), together with VR, is an effective technique to treat disorders for veteran soldiers as well. The central aspect of the intervention consists in providing the soldiers with the opportunity of relating to situations, thoughts and emotions of the traumatic experience with the aim of learning to control his own emotional responses and correct the irrational interpretations connected to the traumatic event.; all within a protected context and through a gradual process that allows the subjects to exclude anything they deem to be unable to deal with at any given time.

Therefore, the high therapeutic potential that VR has in the treatment of anxiety disorders within the operational cycle of employment and in training to deal with stressful situations and traumatic events has been shown time and again. It is also known how such a technology is significantly effective in the treatment of cognitive disorders in clinical populations with acquired brain damage or suffering from neurodegenerative diseases.

Using a rehabilitation program aimed at compensation or cognitive enhancement could be of great use in all those situations in which the military, upon returning from the operating theater, presents, due to severe stress or to the traumatic events they experienced, a decline in cognitive performance. VR, as it involves perceptual, cognitive and emotional processes at the same time, and thanks to its ecological validity and greater engagement compared to classical methodologies as well, could represent a step forward in the treatment of cognitive disorders and in the reintegration of the military.

3.0 METHODOLOGY

3.1 Cerebrum

The application of VR to mental health is a direct consequence of its potential. Such a technology was initially implemented to help the training of warplane pilots, up to the juxtaposition of engineering and ICT with neuroscience and cognitive psychology. The progress of neurosciences on perceptions, on the elaboration of sensorial signals and on conscience ever had a hand in perfecting both the technology and the overall experience. Rehabilitation has fully entered the fray of "doing 2.0", a new tool towards a more and more effective and environmentally sensitive for users.

Cerebrum integrates exactly within such a milieu; it is an app developed by professionals and experts operating within the field of cognitive rehabilitation, as well as by psychologist and experts of psychiatric rehabilitation, which allows users to fully explore situations simulating everyday reality, something useful to work on the resources and the issues the users may have. The VR experience allows to stimulate sensory-motor learning and not only the symbolic-constructive one, because of the immediateness of such an experience, which allows the expression of coping abilities and makes overall interventions easier.

The theoretical and practical narrative framework the use of Cerebrum as an add-on is a bio-psycho-sociocultural milieu, focused on recovery, therefore putting a great emphasis on the clinical, subjective, functional and social features of any given user.

The app presents itself as a cognitive remediation tool, that is to say a kind of recovery focusing on the features of psychosocial functioning connected with metacognition, social cognition and functioning mediation (namely self-esteem, perceived self-effectiveness, agency, empowerment, motivation and initiative); the stimulation of cognitive functions it is carried out under a hierarchically integrated perspective, where the deficits found in a specific cognitive domain are not only compensated and / or repaired; the users involved are also psycho-educated to control and use these functions in their daily life.

The versatility of the tool therefore makes it deficit-oriented and non-diagnosis-oriented, thus allowing the rehabilitation operator to have an experiential and customizable for stimulation and therapeutic paths. Furthermore, its highly ecological approach allows to stimulate and search for effective and easily generalizable solutions outside the therapeutic-rehabilitative setting. Most of the cognitive remediation techniques take the functions that are most correlated to the user's difficulties into account, such as attention, executive functions and memory, which have been shown to be important indicators of functional outcome and therefore the main targets of this type of therapies.
Training on cognitive functions thus becomes an experiential tool for achieving perceived self-efficacy, self-monitoring, empowerment, self-esteem, motivation, initiative and relational and self-determination aspects.

3.2 The structure and tools used by Cerebrum

Cerebrum offers several tasks having different difficulty levels, designed to adapt to the residual capacity of the users involved.

These exercises have been created based on Evidence Based Medicine (EBM) and Evidence Based Practice (EBP); they are configured as a series of hearing and watching stimuli and use everyday items within real life contexts (such as airplanes, offices, bedrooms, kitchens, parks, cities and bathrooms), remade by using computer graphics. Cerebrum encompasses several different modules, according to the stimulated cognitive skills and every exercise gets introduced to the users who are going to be inserted within any given scenario. The levels concerning *Attention and Working Memory* intend to enhance attentive scanning, selective attention, as well as sustained and divided attention. Based on the specific type of any given exercise, users are going to stimulate visual perception, auditory perception and cognitive flexibility. This module contains 20 levels that take place in different contexts and each of them is associated with an administration and correction sheet. All questions, answers and feedback between the operator and the user are verbal.

The levels making up the *Memory and Learning* module are instead intended for enhancing attentive codification, semantic memory, as well as the storing and retrieval of information. Therefore, based on the kind of exercise, users are going to stimulate selective attention, attentive control, problem solving and visual planning and perception as well. This module contains 22 levels, which occur in different contexts.

Finally, the levels being a part of the *Cognitive Estimates* models allow to enhance cognitive flexibility, strategic planning, reasoning, critical judgment and abstraction: in so doing, users will also stimulate selective attention, visual perception and problem solving. This module contains 10 levels, which occur in different contexts.

3.3 The analysis carried out by Cerebrum

Like modern therapeutic tools and in line with scientific literature, Cerebrum is not based on a categorical diagnostic approach, but rather on a functional one. Therefore, before this tool is used, it is crucial to know about the cognitive functioning that arose from the use of standardized tests and interviews.

The results of the cognitive assessment are essential for planning and personalizing the intervention and important for monitoring progress and therapeutic outcomes. Currently, research phases are being carried out for the validation of the tool (in cooperation with the University of Cagliari) on a starting sample consisting of 60 users, with diagnoses pertaining to the spectrum of psychosis and mood disorders. The intervention and study methodology are currently being published.

To date, to understand the versatility of the tool and its usability, we can rely on a study conducted on usability analysis.

Reference sample. 41 Persons, 20 of which were patients, took part in the initiative. They were chosen at random, by the users belonging to the group of professionals who are a part of the PRoMIND – Servizi per la Salute Mentale Srls company, and 21 persons for the Healthy sample. 19 men and 20 women took part in the survey.

Table 1 : Information about the study between healty sample and users affected by pathologies.

	Patients (20 units)	**Healthy sample** (21 units)
Average age	39,06 years	35,92 years
Average schooling	14,59 years	14,5 years

Main goal: Demonstrate any differences in the use of Cerebrum between healthy sample and users affected by pathologies (psychosis, dementia, intellectual deficit, autism spectrum disorders).

Method: The participants were introduced to virtual reality technology and the therapeutic purpose of Cerebrum in a synthetic way. Subsequently they were exposed to two scenarios / exercises by Cerebrum, a photosphere and a video sphere, made to choose directly by the person among those present (exposure time about 5 minutes). At the end of the experience, the questionnaire shown in Figure 3 was submitted to the participants.

Questionnaire

Feedback on the usage of CEREBRUM /Version 1.0

Sesso = Sex M F
Schooling:____years

1) Can you tell me about the video quality of the experience?

1	2	3	4	5
poor	mediocre	good	very good	Excellent

2) Can you tell me about the audio quality of the experience?

1	2	3	4	5
poor	mediocre	good	very good	Excellent

3) Can you tell me about your feeling of being in the experience and immersed in it?

1	2	3	4	5
Poor	mediocre	good	very good	Excellent

4) Can you please tell me about any and all undesired effects, such as nausea, sense of unreality, sense of emptiness, or other such feelings, you have noticed during your experience?

____

5) Can you please tell me about any and all undesired effects, such as nausea, sense of unreality, sense of emptiness, or other such feelings, you have noticed during the first moments after your experience?

____

6) Can you please tell me about the feelings you have felt
Before the experience________________________
During the experience_______________________
After the experience_________________________

7) Can you please tell me about the overall enjoyment of the experience?

1	2	3	4	5
Poor	mediocre	Good	very good	Excellent

8) Can you please tell me about the interest and the importance that CEREBRUM may have for you during therapy?

1	2	3	4	5
Poor	mediocre	good	very good	Excellent

Figure 3: The feedback questionnaire on the usage trial for Cerebrum

Results and Conclusions. Within the graphs provided below we may see the results concerning the answers, subdivided into the "Patients" and "Healthy" groups and featuring the degree of satisfaction for every participant involved. No differences arose between the two groups (Patients vs Healthy) concerning the perceived quality of both the "Video" and "Audio" experiences (Figures 4 and. 5).

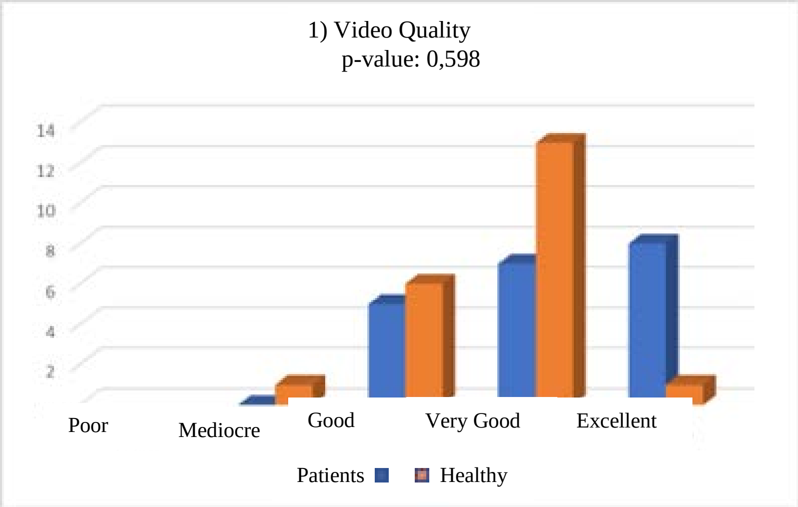

Figure 4: Data on video quality

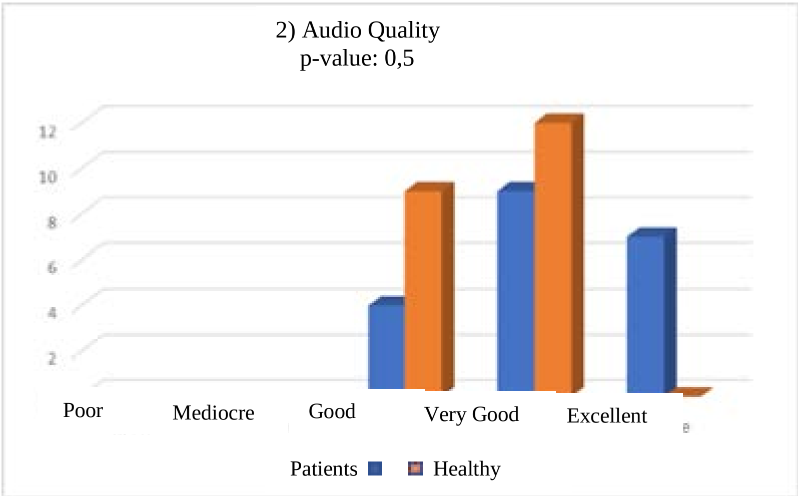

Figure 5: Data on audio quality

Regarding the "Immersivity" characteristic, no significant differences emerged between the two groups (Figure 6), this data was found to be critical for the truthfulness of the experience as it positively correlates with the maximization of the benefits of virtual reality training as meaning of presence, ecology of treatment, facilitation of learning and generalization, emotional involvement and psycho-physical activations, themselves comparable to those connected with "real" experiences.

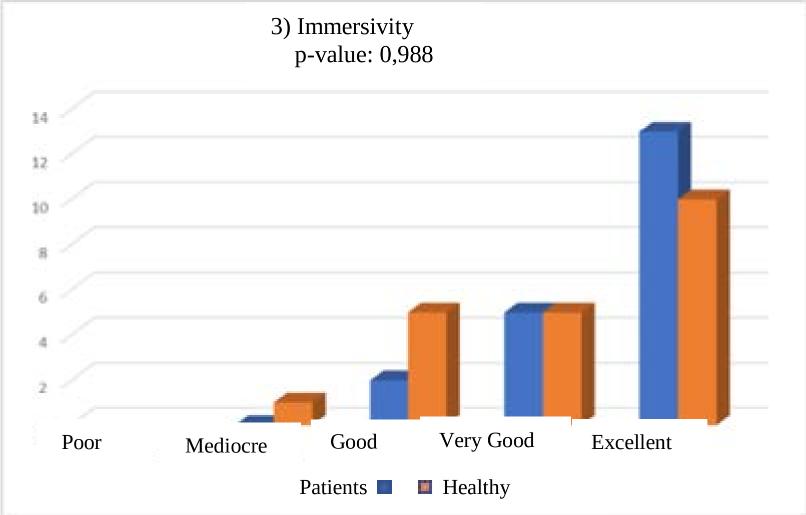

Figure 6: Data on immersivity

Finally, the data emerged on the "*Overall enjoyment of the experience* and on the "*utility*" of the tool (Figures 7 and 8) proved to be invaluable. The strongly positive feedback by users highlighted, as it is the case with the relevant literature as well, that the use of such tools is able to increase compliance and be a wonderful instrument to mediate when therapeutic relationships are concerned. Such aspects, concerning the subject increase of emotional well-being are also connected with a growth in self-efficacy, empowerment and self-esteem.

Given the kind of technology it uses, Cerebrum can be considered as an engaging and attracting professional tool, which is also easy to use and is therefore acceptable, itself a central element to be welcomed by the users it will serve.

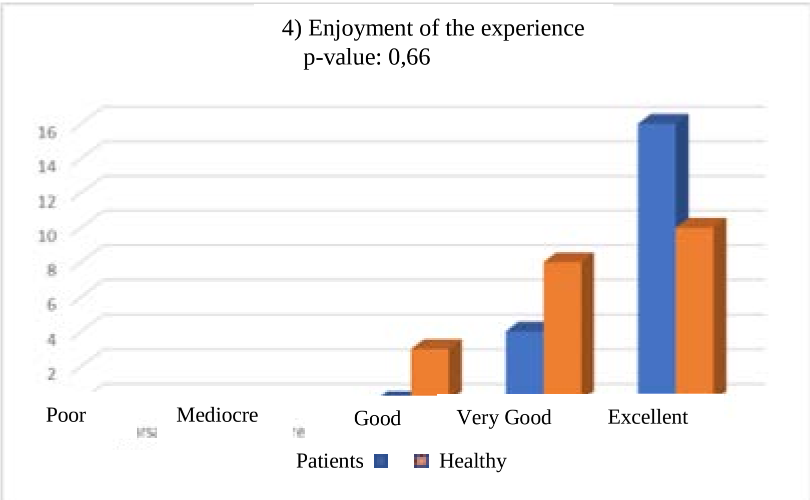

Figure 7: Data on the enjoyment of the experience

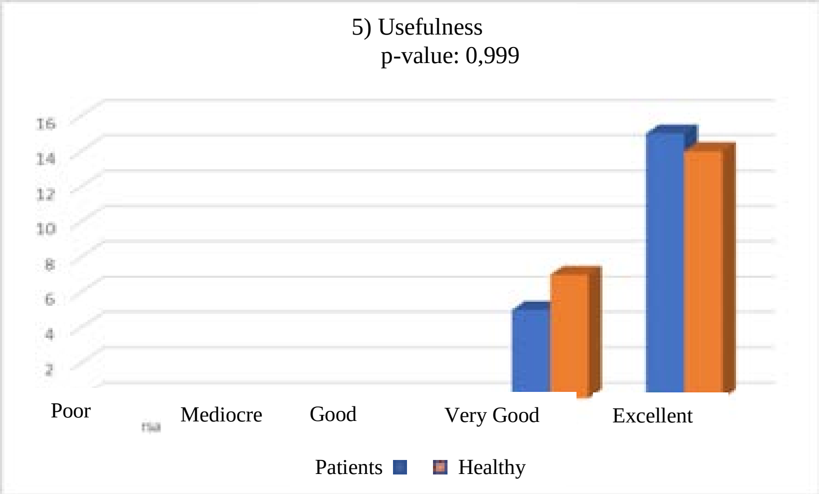

Figure 8. Usefulness data

4.0 CONCLUSIONS

Cerebrum is a software currently under its test and update phases, the app was optimized to be used on more advanced VR visors, featuring better quality and ease of use (namely Oculus Quest 2) compared with the technology used during the initial experiment (i.e., Samsung Gear + Samsung S7), a factor that will allow the instrument to improve the interiorization of experience.

The researchers carried out on the “effects” of VR on users identified that virtual situations are able to trigger body responses being similar to those enacted in the real world, such as changes in the cardiac frequency, in skin conductivity and in peripheral temperature [58].

The cognitive and emotional experience offered by the VR allows patients to become protagonists, and not just observers, of any given experience. From this, a significant degree of environmental-based validity, connecting the therapy-based and rehabilitation situations with those of the real world.

The highly environment-based and realistic scenarios where patients can improve their cognitive performance are many and, as it has been seen from the relevant scientific literature, both efficient and effective.

Given the aforementioned studies, we hypothesize to use Cerebrum not only to trade off and repair damage, but also on subjects which have no evident cognitive deficits, despite the fact that they perform with difficulty, by using the cognitive function and educating users in a psychological way towards a better use of such function, thinking about strategy and focusing on performance mediators. In such cases, neuropsychology- based rehabilitation would increase, through cognitive enhancement, the functional-cognitive skill and brain plasticity, therefore strengthening cognitive performance. An intervention such as the latter would be dedicated to service persons under intense environmental and emotional stimuli, with the goal of preventing damage.

Considering the civilian milieu as well, Cerebrum proved to be a worthy recovery, prevention and announcement tool, able to act on the cognitive function of any given subject, within a theoretical biological, psychological, sociocultural and neuropsychological framework, working both on repairing damage and on performance mediators, in order to enhance cognitive performance and allow the full expression of the skills and resources of any given subject, considering both the effectiveness of their performance and the efficiency of the efforts required.

Concerning the future, we are looking forward to the customization of Cerebrum, as it is a real opportunity for VR, based on the dedicated needs of specific subgroups of military personnel, so that both the tool and the methodology may be focused on people, optimizing the resources to the highest possible degree and emphasizing the main key points of such approaches, that is to say the relationship and organizational level between the operators and the users of the technological- recovery instrument.

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