Volume 14 Year 2016
ISSN: 1554-8716

Annual Review of CyberTherapy and Telemedicine

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ISSN: 1554-8716

14

http://www.arctt.info

Annual Review of Cybertherapy And Telemedicine 2016

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Annual Review of CyberTherapy and Telemedicine

 Interactive Media Institute
6540 Lusk Boulevard, Suite C115
San Diego, CA 92121

ISBN: 1554-8716

Printed in the United States of America

Journal Web site: http://www.arctt.info
Interactive media Institute Website: http://www.interactivemediainstitute.com

Virtual Reality Environments to rehabilitation Attention deficits in schizophrenic patients

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Abstract. Cognitive dysfunction is regarded as a core feature of schizophrenia. Patients with schizophrenia showed poor performance on tasks that require vigilance or sustained attention. The study aimed at developing a Virtual Reality cognitive training to improve the selective, divided and sustained attention. Two clinical samples of patients with schizophrenic disorder were involved: an experimental group treated with pharmacological therapy and Virtual Reality cognitive training; a control group received pharmacological therapy and Integrated Psychological Treatment. Both VR training and IPT were associated with improved performance in sustained attention tasks. After the training, the experimental group showed improvements in planning and divided attention. This preliminary investigation suggests that virtual reality training may improve cognitive functioning in patients with psychosis.

Keywords. Virtual Reality, Schizophrenia, Cognitive Rehabilitation, Sustained Attention.

1. Introduction

Cognitive dysfunction is regarded as a core feature of schizophrenic disorders. Schizophrenia affects transversally all the neurocognitive domains, in particular the functions related to the 'hypofrontality', such as executive functions, speed processing, memory, and attention [1].

Literature described moderate to severe deficits across several domains, including attention, working memory, verbal learning and memory, and executive functions. Cognitive impairment usually arise at the onset of psychosis, is stable throughout the course of the disease, and has been consistently associated with poor social problem solving [2, 3]. Impaired attention is considered to be a fundamental cognitive deficit in patients with schizophrenia [4, 5]. Patients with more severe attention deficits are less successful in psychosocial rehabilitation programs as their impaired attention increases

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the difficulty in information processing, and they may not be able to sustain attention for the session duration [6]. Patients with schizophrenia showed poor performance on tasks that require vigilance, quick responses, or sustained attention [5]. These deficits tend to be stable during episodes of active psychosis as well as remission periods and, therefore, are considered to be vulnerability markers of the disease. Attention impairments correlate with maladaptive functioning [7, 2] and poor response to specific rehabilitation programs, such as social skills training [8].
Recently, Virtual Reality [9, 10, 11] provides opportunities to overcome some of the current limitations of cognitive rehabilitation programs providing valuable scenarios and ecologically valid tasks. The added value of Virtual reality in cognitive rehabilitation, compared to the traditional approaches, are the customization on user's needs; the possibility to graduate the task's difficulty; the high level of control; the ecological validity; and the reduced costs [12, 13, 14]. This study investigated the feasibility of Virtual Reality in improving selective, divide and sustained attention. Specifically, we developed, via the NeuroVr 2.0 software [15], three different virtual environments with a hierarchical sequences of tasks, designed to train specific attention domain.

2. Methods

2.1 Participants

The study involved two clinical samples of patients affected with schizophrenic disorders, diagnosed according to the DSM 5 criteria. The experimental group received a cognitive training based on virtual reality; the control group received Integrated Psychological Treatment (IPT). Additionally, both groups were treated with pharmacological therapy. Demographic information of the sample is reported in Table 1. Patients were recruited from the outpatient Unit of Psychiatry of Palermo University Hospital.

Table 1. Clinical samples

	Experimental group	**Control group**
N	9	6
Age (Mean ± SD)	29 ± 12.05	35 ± 9.9
Gender, male (n, %)	6, 66.6%	6, 100%
Treatment	• Pharmacological therapy • Cognitive training based on virtual reality (once a week)	• Pharmacological therapy • IPT: Integrated Psychological Treatment (once a week) • Other activities such as music therapy, individual/group to improve social skills and autonomy in daily life in a community center

2.2 Instruments and procedures

Before and after the training, all the participants were tested with extensive neuropsychological assessment, to obtain an accurate overview of their cognitive functioning and to compare the performances of the two groups. In particular, the following test were employed: the Mini Mental State Examination to test general cognitive functioning (MMSE), the Frontal Assessment Battery (FAB) to assess executive functions, the Trail Making Test (TMT, Forms A, B and B-A) to assess the sustained and divided attention, the Tower of London test (ToL) to assess planning, the Memory Battery to test brief and long term memory, and the Wisconsin Card Sorting Test (WCST) to test cognitive flexibility. The test scores were corrected for age, education level and gender, when appropriate.

2.3 Interventions

After the neuropsychological evaluation, the experimental group was exposed to a VR attention training consisted of hierarchical sequences of tasks (starting from a single-task condition and ending with successive multiple tasks) settled in three different virtual environment, whose characteristics are below described (Figure 1):

1. Park (sustained attention task): the subject was asked to catch footballs presented at irregular intervals of time, in order to reduce the expectation effect;
2. Valley (selective attention task): the participant was required to identify and pick up a particular type of flower. The increasing difficulty of this task – consisting of four different subtasks – was related to the different characteristics of the target stimulus (first any pink flower, secondly only white and red poppies, then only yellow daisies) and with the complexity of the background (poor of flower vs. rich of flower valley);
3. Beach (selective and divided attention task): the subject had to pick up a particular type of bottles (first only glass bottles, then both green glass bottles and red-cap bottles). Moreover, he was alerted to any calls and loudspeaker announcement: when a voice announced the kiosk's opening time, he had to stop his activity, go to the kiosk, and have a meal.

Figure 1. Virtual environment- park, valley, beach

The use of these three different virtual environments with different interactivity levels and very similar to the real participants' living contexts, allowed us to train a wide variety of functional activities in a laboratorial context. The Virtual Reality cognitive rehabilitation intervention was implemented in 10 individual sessions, on a weekly base. Each session had the duration of approximately 90 minutes and was guided by a predefined protocol. At the first and last sessions, we assessed the following items:

- time of execution;
- total errors;
- request of assistance;
- need for the therapist's interventions;
- "sustained attention" throughout the sequence of the task, not distracted by other stimuli;
- "divided attention" between the different components of task
- "maintained sequence of task";
- "self-corrections" and the "absence of perseveration";
- "maintained task objective to completion".

In order to access to virtual environments we used software the Neuro-VR vers. 2.0, head mounted displays, trackers, a computer and a joypad.
The control group was exposed to 10 group sessions of Integrated Psychological Therapy (IPT) [16], 1 time per week. IPT is a group therapy program for schizophrenia patients and it is based on the assumption that basic deficits in cognitive domains have a pervasive effect on higher levels of behavioral organization, such as social skills as well as social functioning. The IPT is organized in 5 subprograms, arranged in a hierarchical order, according to complexity of the functions. The first 3 subprograms, Cognitive Differentiation, Social Perception, and Verbal Communication, represented the cognitive training components, including abstract reasoning, conceptual organization, basic perception and communication skills training. The fourth and fifth components represent the behavioural level of social interaction and are similar to other skills training programs.

2.4 Statistical analyses

Social and clinical characteristics of the groups were compared using Fisher's exact test and Mann-Whitney test. Wilcoxon test was used to compare pre- and post-training cognitive performances both within the experimental and the control group.

Table 1. Pre- and post-training difference in neuropsychological tests

Test-retest	Experimental (n=9)	Control (n=6)
MMSE	z= -2.232, p= 0.026*	z= -0.210, p= 0,833
ToL	z= -2.032, p= 0.042*	z= -1.225, p= 0.221
TMT-A	z= -2.134, p= 0.033*	z= -1.363, p= 0.173
TMT-B	z= -2.075, p= 0.038*	z= -2.207, p= 0.027*

*Significant $p<0.05$

3. Results and conclusions

At baseline, groups were similar in terms of gender, age, education level, and degree of cognitive impairment (data not shown). Both VR training and IPT were associated with improved performance in the divided attention task (TMT-B). By contrast, our preliminary findings showed that VR training was additionally related with better general cognitive functioning (MMSE), and with improved planning (TOL), and sustained attention (TMT-A) (see Table 1).
Moreover, using our *ad hoc* observational grid, it was found that – after the virtual cognitive training – the experimental group showed:

- reduced time of execution (41.99 ± 28.89 vs. 21.93 ± 11.82; Wilcoxon z test = -2.666, p= 0.008);
- decreases request of assistance (5.77 ± 6.51 vs. 0.77 ± 1.71; Wilcoxon z test = -2.371, p= 0.018);
- decreases needs of the therapist's intervention (51.55 ± 113.49 vs. 26.77 ± 69.22; Wilcoxon z test = -2.666, p= 0.008);
- decreases number of omissions (4.66 ± 5.22 vs. 1.44 ± 2.50; Wilcoxon z test = -2.032, p= 0.042);
- improvement in sustained attention (8.44 ± 2.18 vs. 8.00 ± 1.93; Wilcoxon z test = -2.000, p=0 .046).

These new data, consistent with a previous study [10], provide support for the feasibility of virtual reality training in improving cognitive functions in psychotic patients. We think that some characteristics of VR, such as simulation of daily life situations, might significantly improve traditional cognitive rehabilitation programs, by making them more interesting for patients affected by psychosis and by fostering the transfer of cognitive skills in daily life experience.

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