

# Cognitive Rehabilitation of Schizophrenia Through Neurovr Training

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**Abstract.** Cognitive difficulties are prevalent in people with diagnosis of schizophrenia and are associated with poor long-term functioning. In particular, memory, selective, divided and sustained attention and executive functions are altered by this disease. We used a Virtual Reality environment (developed via the NeuroVr2.0 software) for the rehabilitation of shifting, sustained attention and action planning functions using tasks reminiscent of daily life tasks. Test and retest showed significant differences in the assessed cognitive dimensions.

**Keywords.** Virtual Reality, Schizophrenia, Cognitive Rehabilitation, Executive functions.

## Introduction

Schizophrenia is a mental disorder characterized by a breakdown of thought processes and by poor emotional responsiveness, such as abnormal expressions of emotion and ways of thinking, mental derangement, regression from reality, strange language or behaviour and delusion or illusions. Cognitive impairment is a core feature of schizophrenia, and is present in the majority of patients, independent of positive symptoms such as delusion and hallucinations, with converging evidence showing that it is strongly related to functioning in areas such as work, social relationships, and independent living [1]. Furthermore, cognitive functioning is a robust predictor of response to psychiatric rehabilitation [2, 3]. Schizophrenia transversally affects all of the neurocognitive functioning domains, in particular the functions related to the “hipofrontality”, such as executive functions, processing speed, memory, and attention [4]. We developed - via the NeuroVr 2.0 software - a Virtual Reality (VR) cognitive task, for rehabilitation of shifting, sustained attention and action planning functions (problem solving, planning, working memory, inhibition, mental flexibility, initiation and monitoring of actions). Virtual Reality provides opportunities to enlarge the actual limits of cognitive rehabilitation applications providing valuable scenarios with common elements for the patients, putting them in contact with daily life activities. Immersive virtual environments appear to be the best solution to make lab situations become closer to the natural setting in the subject’s perception.

According to other authors [5, 6], we believe that the added value of Virtual reality in cognitive rehabilitation, compared to the traditional approaches, is the customization on user’s needs (each virtual environment can be produced in a specific way focusing on

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the patient's characteristics and demands); the possibility to graduate (each virtual environment can be modified and enriched with more and more difficult and motivating stimuli and tasks); the high level of control (it allows professionals to monitor the level of affordability and complexity of the tasks that can be provided to patients); the ecological validity (a virtual environment allows to stimulate in the subjects emotional and cognitive experiences like in the real life); and the costs reduction (rehabilitation with Virtual Reality can be cheaper than the traditional one, mostly when it comes to the reconstruction of complex scenarios).

## **1. Methods**

### *1.1 Participants*

The study included two clinical samples of patients suffering from schizophrenia disorder diagnosed by DSM IV with no history of neurological disease, recruited at the outpatient Unit of Psychiatry of Palermo Universitary Hospital.

The experimental group consisted of 6 patients (mean age=31 years, std.dev.=14.6) treated with pharmacological therapy and with cognitive training based on virtual reality (once a week). The control group was composed of 6 patients (mean age=35 years, std.dev.=9.9). They received pharmacological therapy, Integrated Psychological Treatment (IPT) (once a week). Moreover these patients used to frequent a community centre to participate in other activities such as music therapy and individual/group activities to improve social skills and autonomy in daily life.

Exclusion criteria were: motor impairment which does not allow subject to perform the virtual procedure; presence of severe difficulties in visual discrimination skills and language comprehension; absence of psychiatric comorbidity.

### *1.2 Instruments and procedures*

Before and after training we assessed the cognitive and executive functions, both in cases and controls, through following tests: the Mini Mental State Examination (MMSE), Frontal Assessment Battery (FAB), the Trial Making Test (TMT), the Tower of London (ToL), the Memory Battery, the Wisconsin Card Sorting Test (WCST), and the Stroop Colour Word Test.

### *1.3 Interventions*

The experimental group was exposed to a virtual attention and executive-function training consisted of hierarchical sequences of tasks (starting from a single-task condition and ending with successive multiple tasks) settled in four different virtual environments, whose characteristics are described below (Figure 1):

1. Park (sustained attention): the subject was asked to catch footballs presented at irregular intervals of time, in order to reduce the expectation effect;
2. Valley (selective attention): 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): the subject had to pick up particular types 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;
  4. Supermarket (executive function): the participant was asked to collect and buy several products from a shopping list. The products were presented in categories including food, hygienic products, frozen food, and on-sale products. Furthermore, while doing his shopping the participant had to follow specific rules, i.e. not to go in the same aisle more than once, not to enter an aisle unless the participant needs to collect something in it [7].



**Figure 1:** virtual environments:- park, valley, beach, supermarket

The treatment was implemented in 10 weekly individual sessions. Each session lasted 90 minutes. During the training, the patients' performance was registered using two similar observational grids that provided quantitative indicators. In attention training (park, valley and beach) we evaluated:

- time of execution;
- total errors, with a score ranging from 49 (the subject has correctly done the tasks) to 98 (the subject has totally omitted the tasks);
- partial errors whit a scoring range from 7 (no errors) to 14 (more errors).

Items of partial errors are: "pick up all objects"; "sustained attention"; "divided attention"; "maintained sequence of task"; "self-corrections"; "absence of perseveration"; "maintained task".

In executive function training (virtual supermarket) we used a grid to measure [8]:

- time of execution;
- total errors, with a score ranging from 11 (the subject has correctly done the tasks) to 33 (the subject has totally omitted the tasks);
- partial tasks failures, with a score ranging from 8 (no errors) to 16 (great errors);
- inefficiencies, with a score ranging from 8 (great inefficiencies) to 32 (no inefficiencies);

- rule breaks, with a score ranging from 8 (many rule breaks) to 32 (no rule breaks);
- strategies, with a score ranging from 13 (good strategies) to 52 (no strategies);
- interpretation failures.

The control group was exposed to 10 60-minute group sessions of Integrated Psychological Therapy (IPT) [9], 1 time per week. IPT is based on a building-block model that assumes basic neurocognitive functions are necessary prerequisites for higher-order complex social functions. The IPT proceeds through 5 subprograms, arranged in a hierarchical order according to complexity of function. The first 3 subprograms represented the cognitive training component, including abstraction, are conceptual organization, basic perception and communication skills training. These IPT function domains are designated Cognitive Differentiation, Social Perception, and Verbal Communication. The fourth and fifth components represent the behavioural level of social interaction and are similar to skills training approaches used elsewhere.

### *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. All analyses were carried on using SPSS v. 19.

## **2. Results**

At baseline, groups were similar in terms of gender, age, education level, and degree of cognitive impairment. Both VR training and IPT were associated with improved performance in the divided attention task. Furthermore, VR training was related with reduced cognitive deficits and improved planning (Table 1).

**Table 1.** Results at Wilcoxon test

Test-retest	Experimental (n=6)	Control (n=6)
MMSE	$z = -2.020$ , $p = 0.043^*$	$z = -0.210$ , $p = 0.833$
ToL	$z = -2.032$ , $p = 0.046^*$	$z = -1.841$ , $p = 0.066$
FAB	$z = -1.826$ , $p = 0.068$	$z = -1.787$ , $p = 0.074$
TMT-B	$z = -2.023$ , $p = 0.043^*$	$z = -2.207$ , $p = 0.027^*$

\*Significant  $p < 0.05$

After the executive function training (virtual supermarket) the experimental group showed significant improvements in: decreased errors ( $20.33 \pm 2.7$  vs.  $15 \pm 2.36$ ; Wilcoxon  $z$  test =  $-2.02$ ,  $p = .043$ ); reduced time of execution ( $10.47 \pm 3.31$  vs.  $4.42 \pm 1.91$ ; Wilcoxon  $z$  test =  $-2.20$ ,  $p = .028$ ); increased observance of rules ( $17.33 \pm 3.9$  vs.  $22.33 \pm 3.4$ ; Wilcoxon  $z$  test =  $-2.21$ ,  $p = .027$ ). In addition, after the attention training (park, virtual valley and beach), the experimental group showed improvements in: reduced time of execution ( $54.00 \pm 28.71$  vs.  $25.56 \pm 13.26$ ; Wilcoxon  $z$  test =  $-2.20$ ,  $p = .028$ ); decreased perseverative errors; improvement in sustained attention.

### 3. Conclusions

These preliminary data suggest that virtual reality training may improve cognitive functioning in psychotic patients and others in rehabilitative programs.

We think that characteristics of VR training (such as low costs or daily life reproduction) makes it very useful with schizophrenic people. Moreover, 90 minutes sessions do not allow the patient to fatigue or bore. Furthermore, if we compare the two samples we find similar results, but the experimental group is involved in only VR training. The control group spends much more time doing daily activities.

A small sample size is required to carry on with this study to verify our preliminary data.

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