Virtual reality and neuropsychology: a cognitive rehabilitation approach for people with psychiatric disabilities

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ABSTRACT

This pilot-study evaluated the feasibility of a 9 month Cognitive Rehabilitation Program – using Virtual Reality and the Integrated Psychological Therapy (IPT) – to improve cognitive functioning in people with schizophrenia. In order to assess the program it was applied (pre and post) the WCST, WAIS-III sub-tests, Stroop Test, and The Subjective Scale to Investigate Cognition in Schizophrenia. Results identified significant differences ($p<0.05$) between pre and post tests in the subjective and objective assessed cognitive dimensions. The results point out that virtual reality technology and IPT may be a significant resource and intervention methodology in the cognitive remediation of people with psychiatric disabilities.

1. INTRODUCTION

Schizophrenia is a stress-related, neurobiological disorder characterized by disturbances in the form and content of an individual's thought and perceptual processes, affect, social, and instrumental role behaviour. The pervasive impact of schizophrenia across perceptual, cognitive, emotional and behavioural domains, as well as the heterogeneity within those domains requires a multimodal and comprehensive approach to treatment and rehabilitation which involves the individual and his or her environment.

However, cognitive impairment it has come to be seen (since the 1980s) as a core feature of the disorder and an important determinant of course of illness, reliably present in the majority of patients, independent of positive symptoms such as delusions and hallucinations, a major cause of poor social and vocational outcome, and may interfere with the individual capacity for benefiting from psychosocial rehabilitation, especially when such intervention involves learning new skills (Goldberg et al., 1990; Green et al., 1996; Romero, 2003). Schizophrenia affects transversally all the neurocognitive functioning domains, in particular the functions related to the 'hipofrontality', such as executive functions, processing speed, memory (with special incidence in work memory), and attention (Brazo et al., 2005).

Other studies have already demonstrated that persons with schizophrenia present difficulties in terms of emotional recognition and social perception. Social perception is even being pointed out as a mediator between basic cognitive activity and social function (Kohler et al., 2000; Penn et al., 1997; Vauth et al., 2004). On other hand, there are studies indicating a strong link between neurocognitive factors, daily life activities, social problem resolution, social competencies development, and psychosocial functioning (Green et al., 1996, 2000).

The perceived impact of cognitive impairment on day-to-day functioning has led to the development of cognitive rehabilitation approaches intended to remedy these impairments, and thus improve the functioning of people with psychiatric disabilities.

In this context, professionals from different fields of action have been studying and developing cognitive rehabilitation strategies, generating controversy, and a variety of views regarding the effectiveness of each one. In general, these approaches may be classified as restorative or compensatory, as well as computerised and non-computerised. In order to distinguish and illustrate these different classifications, we will essentially refer to the approaches identified on the "Training Grid Outlining Best Practices for Recovery and Improved

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Outcomes for People With Serious Mental Illness", developed by the American Psychological Association Committee for the Advancement of Professional Practice in 2005.

The restorative approaches aim to improve cognitive functioning through a set of specified training interventions. It may be more accurate to describe these programs as "cognition enhancing" efforts (Velligan et al., 2006). Some examples of de cognition enhancing approaches are the "Attention Process Training" developed by Sohlberg and Mateer (1987), the "Neurocognitive Enhancement Therapy" program of Bell and colleagues (2001), and the "Computer-Assisted Cognitive Remediation Program" (CARC) created by Bellack and collaborators in 2005. The compensatory approaches aim to bypass or "compensate" for cognitive deficits to promote skill acquisition or functional outcome. Impairments in cognition are circumvented either by recruiting relatively intact cognitive processes or by utilizing environmental supports and adaptations to cue and sequence target behaviours (Velligan et al., 2006). The "Errorless learning" (Kern et al, 2002, 2003) and the "Cognitive Adaptation Training" (Velligan et al., 2000, 2002) are some examples of compensatory programs.

In terms of the other classification, the computerised methods usually base their intervention strategy in the "Retrainning Model", which has as its assumption individualized and specific training for each of the cognitive functions deficit through repeated instructions and exercises, with or without guided practice. Despite other, we would like to highlight the cognitive rehabilitation programs developed by Belluci and collaborators in 2003, designated "Captain's Log Software", and the "Computer-Assisted Cognitive Remediation Program" (Bellack et al, 2005). In what concerns not computerised methods it is possible to identify in the specialist literature (Belluci et al., 2003; Brazo et al., 2005; Krabbendam & Aleman, 2003; Velligan et al., 2006) references to approaches involving paper and pencil exercises/activities developed in group context, psychoeducative programs, as well as broader group intervention programs targeted not only for the development of cognitive skills but also for the social functioning, such as the "Integrated Psychological Therapy" (IPT) developed by Brenner and colleagues (1994), the "Attention Shaping" (Silverstein et al., 2005), The "Frontal / Executive Program" developed by Delahunty and Morice (1993), and the "Cognitive Remediation Therapy" developed by Wykes and colleagues (1999, 2005).

However there are also some approaches allying both computerised and non-computarised methods, which seem to present interesting results. The "Cognitive Enhancement Therapy" designed by Hogarty and Flesher in 1999, and the "Neuropsychological Educational Approach to Rehabilitation" developed by Medalia and collaborators (2005) are some examples that combine computer-based cognitive exercises with small groups training.

The heated debate and controversy surrounding the impact of all these cognitive rehabilitation methods on cognitive skills learning and generalization does not spread to the importance attributed by most experts to the influence of neurocognitive factors in the day to day activities performance (Green et al., 1996, 2000; Kohler et al., 2000; Lysaker et al., 2005; Penn et al., 1997; Vauth et al., 2004).

Recently Virtual Reality based software is thought to be potentially more representative of every-day life situations than paper-and-pencil treatment procedures or traditional computerized approaches (Pugnetti et al., 1998). 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 to 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. Vincelli and colleagues (2001) have considered Virtual Reality as the most advanced evolution of the relationship between man and computers, different from other technologies because it offers to users the chance to experience psychological states of *immersion* and *involvement* (Rizzo, Wiederhold, & Buckwalter, 1998) due to the combination of hardware and software tools with particular interactive interfaces.

Virtual Reality is a technology used in many applications, from arts to health care, in many areas, such as phobias, eating disorders, sexual disorders, and depression psychotherapy, cognitive rehabilitation and psychical rehabilitation (Costa & Carvalho, 2004; Glantz et al., 2003; Schultheis & Rizzo, 2001). In particular, in the rehabilitation field, the possibility to use virtual reality technologies has been studied and the potential based applications has been recognized (Broeren et al., 2002; Campbell, 2002; Cunningham & Krishack, 1999; Grealy & Heffernan, 2000; Pugnetti et al., 1998; Rizzo & Buckwalter, 1997; Schultheis & Rizzo, 2001).

Our view is consistent with other authors (Castelnuovo et al., 2003; Rizzo et al., 1998), who believe that the added value of Virtual reality in cognitive rehabilitation, compared to the traditional approaches, are the *customization on user's needs* (each virtual environment can be produced in a specific way focusing on 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).

Due to the great flexibility of situations and tasks provided during the virtual sessions, considering time, difficulty, interest, and emotional engagement, this new technology allows, besides the diagnostic applications (Zhang et al., 2001), to enhance the restorative and compensatory approaches in the rehabilitation process of cognitive functions inside the traditional clinical protocol.

The reduced number of studies developed in this field, associated to the need of stimulating both basic cognitive functions (like executive functions, processing speed, work memory, and attention), and social-cognitive competencies (like social perception, verbal communication, social competencies and inter-personal problem resolution), was determinant to our program philosophy. This articulates virtual reality (directed to basic cognitive competencies development) with groups sessions (orientated to the social-cognitive competencies development), based on the "Integrated Psychological Therapy" (Brenner et al., 1994).

In this sense, the purpose of this study was to verify the feasibility of a Cognitive Rehabilitation Program – using Virtual Reality and Integrated Psychological Therapy (IPT) (Brenner, 1994) - to improve cognitive functioning in people with schizophrenia.

2. METHODS

2.1 Participants

14 persons with schizophrenia diagnostic (based on the DSM-IV-TR criteria - American Psychiatric Association, 2000) addressed by the "Familiars, Users, and Friends of the Magalhães Lemos Hospital" (Porto, Portugal) participated in this study. Generically the sample was predominantly male (66,7 %), with ages between 23 and 44 (x=32,0;s=6,69), single (80%), unemployed (100%), and with low qualification level (60% had the 9th schooling grade or lower – compulsory schooling level in Portugal).

2.2 Instruments and procedures

The cognitive rehabilitation program we developed was implemented in the "Competencies Development Centre" in Matosinhos, Portugal, and it ran over 9 months long. The program integrated a group intervention orientated for the social-cognitive competencies development, based on the Integrated Psychological Therapy (Brenner et al., 1994), and an individual intervention directed for the cognitive rehabilitation. This resorted to the use of Virtual Reality for intervening in the most affected cognitive functions in schizophrenia – memory, attention, processing speed, and executive functions (Brazo et al., 2005; Carter et al, 1998; Cornblatt & Keilp, 1994; Landro, 1994; Poole et al., 1999; Spindler et al., 1997; Weickert et al., 2000; Weinberger et al., 1994; Wykes & Van der Gaag, 2001).

IPT is based on a building-block model which assumes that basic neurocognitive functions are necessary prerequisites for higher-order complex social functions. Training was conducted in small groups of 7 patients in 60 minute sessions 2 times per week, and proceed through 5 subprograms, arranged in a hierarchical order according to complexity of function. The first 3 subprograms represented the cognitive training component, including abstraction, 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. These are named Social Skills and Interpersonal Problem Solving. Training is highly structured and manual-driven. Some studies have already demonstrated the efficacy and the cognitive and psychosocial benefits of the Integrated Psychological Therapy (Spaulding et al., 1999; Penadés et al., 2003).

The cognitive rehabilitation intervention recurring to the Virtual Reality was implemented in 20 individual sessions, occurring weekly. Each session had the duration of 50 minutes and was guided by a predefined and tested task protocol. From the available virtual reality environments, we opt to use the "Integrated Virtual Environment for Cognitive Rehabilitation -AVIRC" developed by the Rio de Janeiro Federal University, Brasil, (Costa & Carvalho, 2004), and an adaptation of the "Virtual Environments for Panic Disorder – VEPD" from the Auxiologic Italian Institute (Vincelli et al., 2000), consisting in a hypermarket, a Metropolitan and a Square. The use of these four different virtual environments with different interactivities levels and very similar to the real participants living contexts, promoted a huge diversity functional activities in laboratorial context. This was crucial for enhancing the learning generalization and transferring level.

Generically AVIRC integrated a city with streets, cars, furnished houses, a church, shops and a supermarket, which may be visited by participants and where they are asked to make some specific tasks. These require the use of cognitive functions, such as turning off the light when leaving home, turn on the radio, getting in the yellow car. In the VEPD square, among others, there is a coffee house with terrace and different persons seating and walking. The metropolitan context permits the participant to make a journey within the tube, experiencing different lines, and different stations. The supermarket virtual environment reproduces a commercial space with several products available in different shelves, workers helping, clients asking for help, and payment points.

In order to access to virtual environments it was used a computer, a monitor with high level of resolution capacity, Amplified Speakers, and an immersive virtual reality environment equipment, specifically the "I-Glasses 3D-PRO" and a "Virtual Reality Head-Tracker". The "I-Glasses 3D-PRO" permitted to the user obtaining three-dimensional visual information, which makes it appear very close to the reality scenarios. The "Virtual Reality Head-Tracker" permitted that the image gained movement conducted by the user's head movements, promoting in this way the interactivity. These equipments associated to a light and sound isolated room created the necessary conditions to facilitate the immersion in the virtual environment and the performance simulation very close to the real context.

To assess the program effectiveness we used the Wisconsin Card Sorting Test (WCST), Wechsler Adult Intelligence Scale (WAIS-III) sub-test, Stroop Test, and The Subjective Scale to Investigate Cognition in Schizophrenia (SSTICS) – all of them applied pre and post program. We decided to ally objective measure tools (neuropsychologic tests WAIS-III, WCST, and Stroop Test) with subjective measure tools (SSTICS permits analysing the participants subjective assessment in terms of their daily cognitive functioning, based on their day-to-day activities performance self perception) in order to enhance the results reliability, and the analysis extent.

Table 1. *WAIS III* Sub-*testes Results (before and after the intervention).*

Item	Stage	x	s	z	p	Differences	(n=14)
Picture Completion		18,14	3,94	-2,476	0,013*	Negatives	3
		20,64	2,30			Positives	10
Vocabulary		39,71	12,49	-2,171	0,030*	Negatives	3
		44,14	15,27			Positives	11
Digit Symbol - Coding		48,93	12,66	-1,571	0,116 NS	Negatives	4
		50,14	17,96			Positives	10
Similarities		16,36	6,50	-2,426	0,015*	Negatives	2
		20,29	7,01			Positives	11
Block Design		34,64	12,99	-3,112	0,002**	Negatives	1
		42,29	12,70			Positives	12
Arithmetic		9,29	4,68	-2,720	0,007**	Negatives	1
		12,07	4,71			Positives	11
Matrix Reasoning		12,14	5,54	-2,849	0,004**	Negatives	1
		16,86	5,92			Positives	12
Information		13,71	6,17	-1,847	0,065 NS	Negatives	1
		14,79	5,94			Positives	9
Picture Arrangement		10,43	5,95	-1,980	0,048*	Negatives	2
		12,43	5,69			Positives	10
Comprehension		16,86	7,75	-1,023	0,306 NS	Negatives	4
		17,71	8,76			Positives	8
Digit Span		15,79	3,36	-2,549	0,011*	Negatives	2
		19,07	4,50			Positives	12
Symbol Search		24,57	6,64	-2,633	0,008**	Negatives	2
		28,36	5,33			Positives	11
Letter-Number Sequencing		8,14	2,88	-2,051	0,040*	Negatives	3
		10,07	3,54			Positives	9
Object Assembly		30,64	10,52	-1,508	0,32 NS	Negatives	5
		34,00	9,58			Positives	8

*p<0,050 **p<0,010

3. RESULTS

Table 1 presents WAIS III pre and post subtest results. Statistic analysis reveals a significant increase in the scores of Picture Completion, Vocabulary, Similarities, Picture Arrangement, Digit Span, Letter-Number Sequencing (p<0,050), Block Design, Arithmetic, Matrix Reasoning, and Symbol Search (p<0,010). In what concerns the scores on Digit Symbol – Coding, Information, Comprehension, and Object Assembly significant differences were not identified.

Results point out as well (Table 2) that at the end of the program individuals presented a significantly inferior number of errors (p<0,010) and of perseverative errors in *Wisconsin Card Sorting Test* (p<0,050). They have completed a significantly major number of categories (p<0,050). Significant differences on correct answers were not identified.

Table 2. *Wisconsin Card Sorting Test Results (before and after the intervention).*

Item	Stage	x	s	z	p	Differences	(n=14)
Correct Responses Trials	Pre	75,36	11,39	-0,251	0,802 NS	Negatives	6
	Post	73,71	9,41			Positives	8
Number of Errors	Pre	45,86	18,84	-2,691	0.007**	Negatives	11
	Post	31,79	20,18			Positives	2
Non-perseverative errors	Pre	21,43	8,62	-1,477	0,140 NS	Negatives	9
	Post	17,29	12,07			Positives	5
Perseverative answers	Pre	32,71	19,87	-2,168	0.030*	Negatives	10
	Post	19,93	15,17			Positives	3
Perseverative errors	Pre	24,43	15,41	-2,136	0.033*	Negatives	10
	Post	14,64	11,26			Positives	4
Categories	Pre	4,21	1,67	-2,401	0.016*	Negatives	1
	Post	5,29	1,64			Positives	8

*p<0,050 **p<0,010

Results presented in Table 3 indicate that individuals demonstrated a significantly better performance in the Word, and Word-Color (p<0,010) of the Stroop subtest. There are not significant differences on the Colors and Interferences score.

Table 3. *Stroop Test Results (before and after the intervention).*

Item	Stage	x	s	z	p	Differences	(n=14)
Word	Pre	33,43	8,82	-2,633	0,008**	Negatives	2
	Post	39,14	7,85			Positives	10
Color	Pre	34,93	7,44	-0,565	0,571	Negatives	5
	Post	36,00	6,42			Positives	9
Word-Color	Pre	33,07	6,34	-3,206	0,001**	Negatives	1
	Post	39,36	7,74			Positives	13
Interference	Pre	48,79	8,44	-0,210	0,834	Negatives	6
	Post	49,43	8,92			Positives	7

*p<0,050 **p<0,010

Finally, Table 4 shows the results on the participants subjective perception in terms of their own cognitive performance. In the SSICS the higher scores refer to the difficulties felt in cognitive functioning. In this terms, we may verify that after the intervention program individuals obtained significantly inferior results in what concerns the total score (p<0,010) and almost assessed dimensions: explicit memory and global perception (p<0,010), working memory, attention, executive functioning, and language (p<0,050). Only in praxia dimension there was no significant differences.

Table 4. *Subjective Scale to Investigate Cognition in Schizophrenia Results (before and after the intervention).*

Item	Stage	x	s	z	p	Differences	(n=14)
Working Memory	Pre	5.86	1.29	-2,223	0.026*	Negatives	8
	Post	4.79	1.19			Positives	2
Explicit Memory	Pre	21.21	3.83	-2,769	0.006**	Negatives	10
	Post	18.50	3.06			Positives	1
Attention	Pre	15.86	3.18	-2,419	0.016*	Negatives	10
	Post	13.21	2.99			Positives	3
Executive Functioning	Pre	8.64	2.50	-2,023	0.043*	Negatives	8
	Post	7.07	1.63			Positives	1
Language	Pre	3.00	0.96	-2,333	0.020*	Negatives	6
	Post	2.21	0.80			Positives	0
Praxia	Pre	2.00	0.96	-1,830	0.059 NS	Negatives	6
	Post	1.64	0.93			Positives	1
Total Score	Pre	55.93	9.30	-2,922	0.003**	Negatives	12
	Post	47.29	7.35			Positives	2

*p<0,050 **p<0,010

4. CONCLUSIONS

Results identified significant differences (p<0.05) between pre and post tests in the subjective and objective assessed cognitive dimensions. There was a significant improvement in the cognitive performance, namely in the ability of perceptual organization (Picture Completion, Block Design and Matrix Reasoning), in working memory (Arithmetic, Digit Span and Letter–Number Sequencing), processing speed (Digit Symbol, Coding and Symbol Search), attention (Stroop Test), and the executive functions (WCST). It was also identified that the intervention program appeared to have improved the verbal comprehension (Vocabulary, and Similarities) despite we did not found significant differences in the Information sub-test.

Simultaneously the relapse and re-hospitalized rate (6,7%), drop out rate (0%), attendance rate (91%), and punctuality rate (85%) verified are the example of the high level of participants motivation and satisfaction, which has to be considered as an other success indicator.

The results point out that virtual reality technology and IPT may be a significant resource and intervention methodology in the promotion of cognitive competencies in people with psychiatric disabilities. However, considering that this research represents only a pilot study (obviously with some limitations, such as the inexistence of control group or the reduced number of participants), it is essential that further investigation is made on this field.

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