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Using virtual reality to evaluate executive functioning among persons with schizophrenia: A validity study

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ABSTRACT

Persons with Schizophrenia experience difficulties with Executive Functioning (EF) that affect independence and participation in activities. Specifically, EF impacts performance in Instrumental Activities of Daily Living (IADL) that require flexible thinking and accommodation to complex environments. However, less is known how schizophrenia affects EF and individuals' performance in activities. IADL performance can be tested using a virtual reality (VR) environment that simulates real life activities. The purpose of this study was: 1) to examine the feasibility and validity of the Virtual Action Planning-Supermarket (VAP-S) to assess EF in persons with schizophrenia as compared to a standardized EF measure (the Behavioral Assessment of Dysexecutive Syndrome, BADS); 2) to compare performance of persons with schizophrenia and healthy controls in the VAP-S; 3) to assess the ability of the VAP-S to differentiate between different levels of EF within schizophrenia; 4) to explore the relationships between negative and positive symptoms and performance on the tests. Thirty persons with schizophrenia were matched with 30 healthy controls. Significant differences in performance between research and control groups were detected on the VAP-S and BADS, with the research group performing worse. Large variations in number of purchases within the VAP-S by the research group point to level of task completion thus secondary analysis was conducted. There was a significant negative correlation between level of the negative signs and overall performance on the BADS and on most measures of the VAP-S. Results of this study support the use the VAP-S to assess EF among persons with Schizophrenia.

1. Introduction

Persons with schizophrenia can experience significant cognitive impairments such as reduced attention and memory, slowed information processing, and difficulties with higher mental functions including Executive Functioning (EF) and meta-cognitive skills (Bryson et al., 2001; Hutton et al., 1998; Josman, 2005; Pantelis et al., 1997; Posada et al., 2001). EF and meta-cognition (i.e. ones knowledge regarding personal thinking processes) are among the higher functions of the human mind. Impairments in higher mental functions lead to difficulties in Instrumental Activities of Daily Living (IADL) (Katz & Hartman-Maeir, 2005) which are complex tasks that require interaction with the environment and manipulation of objects (such as a telephone or a motor vehicle) (Goverover, 2004). Performance levels in IADL are indicative of independent functioning and strong predictors of rehabilitation outcomes and quality of life among different clinical populations (Goverover, 2004).

Cognitive-related research in schizophrenia examining the link between reduced EF and meta-cognitive abilities and individuals' ability to perform daily activities have found that persons with schizophrenia who exhibit lower EF performed worse in IADL (Josman & Katz, 2006; Seacrest et al., 2000). In most of these studies, EF was measured using neuropsychological tests. Although these tests provide important information about cognitive impairments, they have low ecological validity and

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therefore have limited ability to predict functioning in daily activities (Chaytor et al., 2006). The term ecological validity which refers to the representativeness of a task is central in the area of assessment of EF because these are closely associated with real life complex situations (such as shopping, preparing a meal, or medication adherence) that require planning, organization, and structuring (Burgess et al., 2000). Other assessments (such as the Executive Functions Performance Test (EFPT)) that have a greater focus on functional capabilities had better success at predicting performance (Katz et al., 2007).

Traditional Executive Functions (EF) assessments typically measure a particular domain of EF (e.g. inhibition), in isolated tasks, and in artificial situations. Such controlled activities do not mirror daily functioning where performance in several tasks is called upon (Chaytor et al., 2006; Odhuba et al., 2005). In addition, functioning is linked to the environment where tasks are performed based on available cues (Burgess et al., 2006). Thus, many cognitive assessments may not adequately reflect performance outside the examination setting. Therefore, in order to accurately measure EF it is recommended that clients be evaluated while performing novel and complex activities that require planning, organization, and adaptation to a changing environment over an extended period of time (Josman & Katz, 2006). The use of VR to assess EF is one way of overcoming the limitations of other types of assessments.

VR enables users to be engaged and immersed in simulated, interactive environments that are similar to real world objects and events (Josman et al., 2008; Klinger, in press). The benefits of VR cognitive evaluations include the ability to objectively measure behavior in challenging, but safe and ecologically-valid environments, while maintaining strict experimental control over stimulus delivery and measurement (Rizzo et al., 2004). Studies that have used VR in cognitive evaluation of persons with EF limitations found that the use of a meaningful context through VR facilitates performance (Zalla et al., 2001). For example, positive results have been found when using a virtual apartment to assess medication compliance among persons with schizophrenia (Baker et al., 2006; Kurtz et al., 2007). In addition, specific impairments that compromise performance manifested during the simulation such as omissions, failure in initiating actions, and purposeless displacements (Josman et al., 2006; Klinger et al., 2006). There are a few virtual environments that simulate a shopping activity and assess EF and IADL in populations with brain deficiencies (e.g. (Lo Priore et al., 2003; Rand et al., 2007)). However, some of the environments are more logistically cumbersome that hinder ease of use in clinical settings and none have been used to evaluate EF among persons with schizophrenia. Therefore the environment chosen to assess EF in this study was the Virtual Action Planning-Supermarket (VAP-S) – a portable software that can be uploaded on a personal computer (Klinger et al., 2004; Marié et al., 2003).

The objectives of the present study were (1) to assess the feasibility and validity of the VAP-S for the assessment of EF in people with schizophrenia as compared to the Behavioral Assessment of Dysexecutive Syndrome (BADS); (2) to compare the performance of persons with schizophrenia and healthy matched controls in the VAP-S; (3) to assess the ability of the VAP-S to differentiate between different levels of EF within schizophrenia; and (4) to explore the relationships between negative and positive symptoms and performance on the tests.

2. Methods

2.1. Participants

Sixty people were included in the study, 30 people diagnosed with schizophrenia (established by medical charts), and 30 matched healthy controls that did not have a diagnosis of mental illness. The research group was recruited from vocational centers for persons with mental health disabilities. Two hundred and ten subjects were screened to determine eligibility to participate in the study and 30 were declared eligible.

Table 1
Sample characteristics.

Variable	Characteristic	Research group ($n=30$)		Control group ($n=30$)	
		Percent	Frequency	Percent	Frequency
Gender	Male	14	46.7	14	46.7
	Female	16	53.3	16	53.3
Marital status	Single	21	70	4	13.3
	Married	3	10	18	60
	Widower	2	6.7	2	6.7
	Divorced	4	13.3	6	20
Education	Elementary	6	20	0	0
	High school without matriculation exams	16	53.3	2	6.7
	High school with matriculation exams	7	23.4	8	26.7
	Academic	1	3.3	20	66.7
		Mean	SD	Mean	SD
Years of education		10.57	1.99	14.57	2.58
Duration of illness (in years)		24.90	11.88	–	–
Number of hospitalization		4.93	3.86	–	–
PANSS (research group only)		Mean	SD	Theoretical range	Operative range
Positive signs		13.81	4.61	7–49	7–26
Negative signs		25.23	6.21	9–63	14–34
General signs		35.50	9.19	16–144	20–54