



# Patterns of association between performance in a natural environment and measures of executive function in people with schizophrenia

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## ABSTRACT

This study examined the relationships between a set of real-world performance measures and a set of executive function measures with a sample of community based individuals with schizophrenia ( $N=80$ ). Participants were given a battery of cognitive tests and were evaluated with a real-world performance measure, the Test of Grocery Shopping Skills (TOGSS). Using canonical correlation analysis, executive functions of planning, problem solving, working memory, and task persistence were significantly related to grocery shopping efficiency and accuracy. Two canonical variates with moderate correlations (0.547 and 0.519) explain that 30% of the variance in the executive function and grocery shopping measures was shared. These results identify patterns of association between executive function performance and the independent living skill of grocery shopping indicating the Test of Grocery Shopping Skills may be considered a sensitive measure of executive function performance in a real-world setting.

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## 1. Introduction

It is accepted that executive dysfunction is one of the “most ubiquitous features” of schizophrenia (Bowie and Harvey, 2005) and that it relates to functional outcomes (Green et al., 2000; Reed et al., 2002). Executive function is predictive of basic self-care skills (Velligan et al., 2000), instrumental activities of daily living (IADL) (Rempfer et al., 2003; Semkowska et al., 2004), work/productivity and social competence (Velligan et al., 2000).

While executive function deficits are quite common among individuals with schizophrenia (Palmer and Heaton, 2000; Barch, 2003), the population demonstrates different degrees of executive dysfunction as some perform in the normal range and others show severe impairment contributing to functional dependence (Simon et al., 2003). The heterogeneous nature of the population is one reason accurate evaluation of executive functions is important.

It has been suggested executive assessments administered in real-world environments may provide valid indicators of individuals' daily deficits experienced outside clinical settings (Shallice and Burgess, 1991; Cripe, 1996). Assessments in natural settings provide an opportunity to see an individual's ability to respond in a dynamic, novel, and unpredictable environment. While measures that mimic real-world situations have been shown to be capable of assessing

executive function (McKibbin et al., 2004), measures that occur in a real-world environment may allow us to better discern specific executive functions.

One such real-world measure is the Test of Grocery Shopping Skills (TOGSS; Hamera and Brown, 2000; Brown et al., 2009). The Test of Grocery Shopping Skills was developed as a performance-based measure of grocery shopping in individuals with schizophrenia and it requires test-takers to locate 10 items in an actual community grocery store. Performance is assessed on two primary outcomes: accuracy, which includes finding the correct item, in the correct size at the lowest price; and efficiency, which includes redundancy (how often shoppers return to an aisle or go down an aisle that does not contain a needed item), and time (total time needed to complete the test) (Brown et al., 2002).

The Test of Grocery Shopping Skills has been examined for reliability and validity as a context-based community function measure (Hamera and Brown, 2000); for construct validity (Hamera et al., 2002); for how a mediator, knowledge of grocery shopping, influences cognition and community functioning (Brown et al., 2006); and for relationships between cognition and the IADL of grocery shopping (Brown et al., 2002; Rempfer et al., 2003). However, these previous studies have not explicitly focused on the role of executive function in grocery shopping as measured by the Test of Grocery Shopping Skills. When Greenwood et al. (2005) used the Test of Grocery Shopping Skills as their community function outcome measure they modified the measure to explicitly reflect executive processes thought to underlie performance. This was accomplished by

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specifically considering route taken around the store in the redundancy outcome. While the Test of Grocery Shopping Skills considers executive processing as a key component to successful performance in community based skills, it was not directly developed as a measure of executive function but as a measure of grocery shopping. Nonetheless, it may be possible to use the Test of Grocery Shopping Skills to assess specific executive functions and in doing so identify which particular problems with executive function interfere with the performance of grocery shopping. As purported by Burgess et al. (2006), this “function-level” measurement of ability in the real-world is a next step in the development of clinically relevant measures of executive function.

Given that impaired executive functions are highly prevalent in schizophrenia and that current cognitive measures vary in their ability to adequately assess executive dysfunction (Donohoe et al., 2005), the intent of this study was to examine the Test of Grocery Shopping Skills as a measure of the executive functions of planning, problem solving, task persistence, and working memory for individuals with schizophrenia. Using a multivariate analysis approach, two general hypotheses were examined:

**Hypothesis 1.** A relationship would be found between the set of neuropsychological measures of executive function and the Test of Grocery Shopping Skills outcomes variable set, suggesting that the Test of Grocery Shopping Skills can be used as a valid measure of executive function.

**Hypothesis 2.** Specific patterns of association will emerge from within the observed relationships between the cognitive measures set and the Test of Grocery Shopping Skills outcome set, representing planning, problem solving, persistence, and working memory.

## 2. Methods

### 2.1. Participants

Eighty individuals with schizophrenia ( $N=47$ ) or schizoaffective disorder ( $N=33$ ) were included in this study. Participants were recruited from three community mental health centers in the Kansas City area. Schizophrenia or schizoaffective disorder diagnosis was confirmed using the Structured Clinical Interview for DSM-IV (First et al., 2002). Individuals with co-morbidities that affected cognition (e.g., a diagnosis of mental retardation, substance abuse) or other significant physical co-morbidities that affected task performance (e.g., blindness) were excluded from the original study.

The average age of the participants was 42.67 years ( $S.D.=8.47$ ; range 24–63 years) with three participants not identifying their age. 41 were females (51%) and 39 were males (49%). Forty five participants identified themselves as African-American (57%), twenty seven as white (34%), and three as multi-racial (4%), two as Hispanic (3%), one as American Indian (1%), one as Asian (1%), and one did not identify a racial/ethnic background. A majority of the participants had never been married (59%;  $n=47$ ). Fifty participants lived independently, seventeen lived with relatives but were largely independent, five lived with relatives but were heavily dependent for personal care, four lived in supervised care housing with live in staff, one was homeless and two did not identify their living situation. Their educational backgrounds extended from eighth grade or below (4%;  $n=3$ ), to some high school (23%;  $n=18$ ), high school graduate (27%;  $n=21$ ), post high school training (1%;  $n=1$ ), college courses (37%;  $n=29$ ), bachelor's degree (6%;  $n=5$ ), and post-graduate education (1%;  $n=1$ ). 85% ( $n=67$ ) of the participants were not working in a paid employment situation at the time of the study.

With regard to medication, data was unavailable for twelve participants. Of the remaining sixty eight participants, sixty three (93%) were prescribed antipsychotic medications, of which fifty six (89%) were second generation antipsychotics. All participants were administered the Scale for Assessment of Negative Symptoms (SANS; Andreasen, 1983a) and the Scale for the Assessment of Positive Symptoms (SAPS; Andreasen, 1983b) as an index of symptom severity. The sums of all positive and negative symptoms (excluding global ratings) were calculated for the SANS and SAPS. Participants had a mean SANS total score of 21.76 ( $S.D.=11.99$ ) and a mean SAPS total score of 24.76 ( $S.D.=15.47$ ).

### 2.2. Measures of executive function

A total of eight measures of cognition were chosen for inclusion in this study. Each of the eight measures was selected for their ability to assess specific components of

executive function, however with the complexity of executive function there is ambiguity and overlap.

*Rey-Osterrieth Complex Figure Test (CFT)* (Lezak, 1995): Participants are asked to copy a complex geometric figure. In an immediate recall trial, they are asked to draw the figure from memory. *The d2 Test of Attention Concentration (d2)* (Brickencamp and Zillmer, 1998): This measure requires the participant to visually scan, demonstrate vigilance, and sustain attention as they search to locate target items on a standard form. *Trail Making Test (TMT)*: Part A of the Trail Making Test requires the participant to connect numbers in ascending sequence, while being timed. For Trail Making Test Part B, which is also timed, the participant draws a line to connect alternating numbers and letters, also in ascending sequence. The outcome measure of interest for the Trail Making Test was the adjusted duration of test (time). The adjusted duration of test score controls for psychomotor effects by subtracting the time score of Trail Making Test A from the time score of Trail Making Test B (Chaytor et al., 2006). *Wisconsin Card Sorting Task (WCST)* (Heaton et al., 1993): This task is best viewed as a global measure of executive function which relies on the integration of multiple neural areas (Cinan and Tanör, 2002). *Controlled Oral Word Association Test (COWAT)* (Benton and Hamsher, 1976): The FAS version of verbal fluency was used. In the first trial participants are asked to say as many F words as they can recall in a one-minute time limit. In the next two trials the letters A and S were presented. *Letter Number Sequencing (LNS)*: In this subtest of the Wechsler Adult Intelligence Scale – III (WAIS-III) (Wechsler, 1997) the participant is asked to listen to strings of alternating letters and numbers of increasing length and repeat them by first sorting the numbers in ascending order, followed by the letters in alphabetical order. The outcome measure of interest is the total number of strings correctly repeated (Donohoe et al., 2005). *Digit Span Backward (DSB)*: Another subset of the WAIS-III (Wechsler, 1997), this measure requires the participant to attend to an orally presented string of numbers and then repeat them in order backwards. The test is scored by number recalled, with possible scores ranging from 0 to 14. *Months Ordering Test of Working Memory (MO)* (Almor et al., 1999): Participants are required to put increasingly long sets of months into correct calendar sequence.

### 2.3. Performance-based assessment

*Test of Grocery Shopping Skills (TOGSS)*; Hamera and Brown, 2000; Brown et al., 2009): The Test of Grocery Shopping Skills requires participants to locate grocery items, in an actual grocery store. The Test of Grocery Shopping Skills outcome measures include shopping efficiency and accuracy. Shopping efficiency examines how efficiently a participant completes the shopping task. This outcome is calculated by determining the number of aisles or sections of the store that the participant enters, and subtracting from this the actual number of aisles required to most efficiently find the 10 items on the list. A lower score represents a more efficient grocery shopping approach.

The Test of Grocery Shopping Skills accuracy outcome is based on a participant's ability to accurately select the correct item, correct size, and lowest price for all ten target item on the grocery list. This outcome is measured on a score of 0–30, with a higher score indicating better accuracy in target selection.

### 2.4. Procedures

#### 2.4.1. Recruitment

Participants were recruited through community mental health centers using flyers and announcements during meetings. An agency recruiter at each site was utilized to assist with recruitment. Once individuals indicated an interest in the study, a research assistant obtained informed consent. The Structured Clinical Interview for DSM-IV (First et al., 2002) was administered and the chart was reviewed to insure that the participant was eligible for participation. All participants were allowed to keep the groceries from the TOGSS testing.

#### 2.4.2. Administration of measures

After giving informed consent, each individual was administered the cognitive measures in this order: Complex Figure Test, d2 Test of Attention, Months Ordering, Trail Making Test, Letter Number Sequence, Digit Span, Controlled Oral Word Association Test, and Wisconsin Card Sort Test. The cognitive measures were administered in a single session with breaks between each measure. These measures were administered by a trained research assistant. This was followed on a subsequent day, by the administration of the performance-based assessment, the Test of Grocery Shopping Skills in a community grocery store. Each of the testing sessions was conducted by a separate researcher, who was blind to the performance in the other testing session.

#### 2.4.3. Statistical analysis

SPSS for Windows, Version 13 was used to analyze the data. Evaluation of assumptions was conducted, screening for normality, linearity, homoscedasticity, outliers, missing data, and multicollinearity. Missing data was estimated for variables with less than 10% missing values. Data reduction analysis was conducted on each variable set using a principal component analysis. Descriptive statistics and frequencies were computed for all remaining variables in each set. A multivariate statistical technique, canonical correlation analysis (CCA), was applied to explore the relationship between the two sets of variables. Tests of statistical significance, Wilk's Lambda and Chi Square analysis, and the Stewart–Love index, a measure of shared variance, were

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