LEARNING POTENTIAL IN PERSONS WITH SERIOUS MENTAL ILLNESS: INVESTIGATING INTRA-INDIVIDUAL DIFFERENCES IN THE LEARNING PROCESS

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LEARNING POTENTIAL IN PERSONS WITH SERIOUS MENTAL ILLNESS: INVESTIGATING INTRA-INDIVIDUAL DIFFERENCES IN THE LEARNING PROCESS

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ABSTRACT

Learning potential has been explored as a possible mechanism to predict positive rehabilitation outcomes in people with SMI (e.g., Green et al. 2000). More recent research has identified a strong relationship between attention and working memory tasks and improvement after training on dynamic assessments (i.e. learning potential), which may indicate a dependence on these key neurocognitive constructs. The primary aim of the current study, to measure the influence of working memory and attention skills within the learning process, is an important next step in current research investigating learning potential in people with SMI. A total of 192 participants with an SMI diagnosis (schizophrenia spectrum, bipolar disorder and major depressive disorder) completed a battery of neurocognitive and psychiatric measures. Participants also completed a test-train-test intervention using the Wisconsin Card Sorting test. Participants were categorized as high performers, learners or non-learner based on their intervention performance. Correlational analyses revealed that large and moderate effect sizes were seen in relationships between learning potential and variables conceptualized to capture working memory and attention. Further, comparison of the strength of correlations

between neurocognitive variables and learning potential showed a stronger relationship with tasks associated with working memory. It has been demonstrated that cognitive performance can serve as an indicator of how well a person will do in response to interventions designed to improve functional outcomes. By measuring learning potential performance, intervention response can be further enhanced by identifying target areas for remediation, such as working memory. Rehabilitation efforts and functional outcomes can be strengthened by a greater understanding of the learning process and knowledge of how people with SMI learn, therefore maximizing the utility of current intervention and community services.

APPROVAL PAGE

The faculty listed below, appointed by the Dean of the College of Arts and Sciences have examined a thesis titled "Learning Potential in persons with Serious Mental Illness; Investigating Intra-Individual Differences in the Learning Process," presented by Amy L. Barnes, candidate for the Doctor of Philosophy degree, and certify that in their opinion it is worthy of acceptance.

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INTRODUCTION

Individuals with psychiatric disabilities differ in illness severity across various symptoms, including cognitive dysfunction. Cognitive deficits in people with serious mental illness (SMI) are well established in the literature and are associated with impairments across a wide range of functioning (Fioravanti, Carlone, Vitale, Cinti, & Clare, 2005). Learning potential is operationalized as the capacity to improve cognitive performance (cognitive modifiability). Learning potential assessment developed in an effort to examine individual differences in cognition (Wiedl, Schottke, Green, & Nuechterlein, 2004). Recent literature has explored learning potential as a possible mechanism by which people can be grouped based on their ability to learn and utilize new information, and has been shown to predict positive rehabilitation outcomes in people with SMI (e.g., Green, Kern, Braff, & Mintz, 2000). However, longitudinal research has shown that the long term effects of learning, particularly with the Wisconsin Card Sorting Test (WCST; Heaton, Chelune, Tally, Kay, & Curtiss, 1993), are not stable, with relatively few people being able to maintain their high performance more than a year later on the same dynamic assessment (Weingartz, Wiedl, & Watzke, 2008).

Therefore, it appears that information “learned” may not be stored or appropriately accessed in long term memory. Although people may not demonstrate long term retention of newly learned information, people identified as learners have better long term rehabilitation outcomes than non-learners (Fiszdon et al., 2006; Green et al., 2000; Sergi, Kern, Mintz & Green, 2005; Watzke, Brieger, Kuss, Schottke & Wiedl, 2008; Watzke, Brieger & Wiedl, 2009; Wiedl 1999; Wiedl, Schottke & Garcia, 2001a). More recent research has identified a strong relationship between attention and working memory tasks and improvement after training on dynamic assessments (Wiedl et al., 2004), which may indicate a dependence of learning potential on these key neurocognitive constructs.

Rehabilitation efforts and functional outcomes can be strengthened by a greater understanding of the learning process and knowledge of how people with SMI learn, therefore maximizing the utility of current intervention and community services. The primary aim of the current study, to measure the influence of working memory and attention skills within the learning process, is an important next step in current research investigating learning potential in people with SMI.

CHAPTER 2

REVIEW OF LITERATURE

Cognitive Deficits Experienced by People with Serious Mental Illness

Cognitive impairment is a clinically prominent feature among people with SMI, including those with psychotic and affective disorders (Nuechterlein et al., 2004; Schretlen et al., 2000). Although there may be diagnostic differences in terms of the severity of cognitive difficulties, research has consistently documented differences in memory, attention, and processing speed among persons with SMI compared to non-psychiatric control groups (Docherty et al., 1996). In a meta-analysis, Fioravanti et al. (2005) found specific impairments in cognitive functioning in people with schizophrenia in the domains of memory, language/IQ, executive functioning, and attention skills. This is consistent with other research providing evidence of significant cognitive impairment in people with schizophrenia (Braff et al., 1991; Nuechterlein et al., 2004). Similarly, research investigating cognitive deficits experienced by people with affective disorders suggests impairment in the cognitive domains of memory, attention, problem solving and executive functioning (Levin, Heller, Mohanty, Herrington & Miller, 2007; Ravnkilde et al., 2002). Studies that combined diagnostic subgroups of people with SMI did not find significant differences in cognitive functioning based on symptom type, thereby supporting the investigation of SMI samples collectively (e.g., Rempfer, Hamera, Brown & Bothwell, 2006; Wadford & Lewine, 2010).

Learning Potential

Cognitive difficulties are common among people with SMI and are often viewed as a treatment target for several reasons, including their relationship with functional difficulties. Investigation of learning potential in people with SMI may provide further understanding of how cognition impacts functioning. Initial theories of learning potential began in the early 1900's with the Russian psychologist Lev Vygotsky (1896-1934). In an effort to comply with national initiatives to end illiteracy in his country, Vygotsky became frustrated with the literacy assessments that were popular during that time. Instead, Vygotsky posited that assessments should include the evaluation of both a person's current learned material and their capacity to learn. Sadly, Vygotsky died at an early age prior to fully developing his theory and political changes resulted in his work being banned and subsequently lost (Kozulin, 1990).

Current interest in learning potential, as it applies to people with SMI, began in the 1980's with the use of dynamic assessment methods (Goldberg, Weinberger, Berman, Pilskin, & Pod, 1987). While traditional or static cognitive measurements involve a single administration, dynamic assessments typically involve a test-train-test paradigm, with the training trial including detailed feedback and task instruction. Changes in performance between standardized trials after directed feedback are theorized to capture the latent construct of learning potential, which is considered an ability to "learn" and utilize new knowledge on subsequent performance of the original assessment.

Research has identified subgroups of people with SMI who are able to improve cognitive performance after training. Goldberg et al. (1987) administered a dynamic assessment protocol of the WCST to participants with schizophrenia and found that participants who received card-by-card instructions during the training trial significantly improved their subsequent performance. Green, Ganzell, Satz, and Vaclav (1990) demonstrated inter-individual differences in WCST performance among people with schizophrenia such that with extensive feedback, some participants demonstrated significant improvement in WCST performance after training. Interestingly, Green et al. concluded that learning potential may serve as an indicator of people who are more likely to benefit from rehabilitation efforts. Early research on cognitive modifiability focused on nomethetic (group) improvements in people with schizophrenia after training (Bellack, Mueser, Morrison, Tierney, & Podell, 1990; Green, Satz, Ganzell, & Vaclav, 1992). However, more recent research has shifted its focus to intra-individual improvements in order to differentiate between people who are able to benefit from the training intervention (learners) and people who do not (non-learners; Wiedl &Wienobst, 1999; Wiedl, Wienobst, Schottke, Green, & Nuechterlein, 2001b).

Learning Potential Categorization

Early research on learning potential in persons with SMI sought to categorize possible learner subgroups according to performance on the WCST after training. Using item response theory methods, Schottke, Bartram, and Wiedl (1993) developed an algorithm to mathematically categorize WCST performance. In the 64-card version of the WCST, there are six rule changes in which a participant would not be expected to anticipate the correct response; therefore a perfect score would be 58 total correct card sorts. Based on the standard error of the measure, a significant change in performance would be at least a 15 point improvement from trial one to trial three. Hence, in a 64-card trial, high scorers were identified as having a pre- and post-test score of 43 or higher, learners were identified as improving by more than 15 points from pre- to post-test, and non-learners were identified as not meeting either of the previous two conditions (Schottke et al.). See Table 1.

Table 1. Wisconsin Card Sorting Test (WCST) Learner Categories.

	Trial 1	Trial 3
High Performers	≥ 43	≥ 43
Learners	< 43	Gain ≥ 15
Non-Learners	< 43	Gain < 15

NOTE: 64-card version; (Schottke et al., 1993; Wiedl & Weinobst, 1999)

From this algorithm, Wiedl and Wienobst (1999) classified participants as “High Performers”, “Learners”, or “Non-learners” based on their dynamic WCST performance. High performers score high on trial one and maintain their high performance on trial three (post training). Learners initially perform poorly on trial one, however significantly improve their performance on trial three after training. Non-learners do not demonstrate statistically significant improvement across trials one and three, regardless of their receiving training on the task.

Dimensional vs. Categorical Comparisons

There have been various categorization strategies of learning potential reported in the literature. This variability likely contributes to inconsistent findings within learning potential research, and limits the generalizability and utility of this research. Thus, recent research has focused on methods of measuring change using dynamic assessments (Fiszdon & Johannesen, 2010; Waldorf, Wiedl, & Schottke, 2009; Weingartz et al., 2008). While categorical classifications of learning potential assign people into groups based on performance, dimensional approaches differ in that they evaluate learning potential as a range of performance, on which individuals vary.

Dimensional approaches to learning potential classification include a pre-post-test difference score (PPD; the difference between trial one and trial three), a gain score (ideal performance divided by actual performance), and regression residuals from predictive models (actual performance compared to predicted performance). In an effort to evaluate the heterogeneous categorization methods, Weingartz et al. (2008) compared dimensional and categorical approaches to learning potential using the dynamic WCST. A total of 115 participants with SMI, including schizophrenia, schizoaffective, and bipolar disorder, completed the dynamic WCST twice over one year. In addition to comparing categorization methods, Weingartz and colleagues also investigated the utility and stability of the various approaches to measuring change across trials.

Categorization into learner subgroups (e.g., Wiedl, 1999) was found to share the largest amount of variance with the WCST pre-test score. Validity evidence also favored a categorical approach rather than a dimensional approach. When using the categorical approach, learner groups demonstrated greater cognitive performance in these areas compared with non-learners. In addition, the categorical approach had better prognostic validity in terms of associations with psychosocial rehabilitation outcomes described above. Learner group categorization was unrelated to positive clinical symptoms (discriminant validity) but was weakly related to negative symptoms. In examining the dimensional approach of using regression residuals, Weingartz et al. (2008) noted that this approach is conceptually limited in that it excludes pre-test performance. Fiszdon and Johannesen (2010) also compared learning potential indices in a sample of 43 people with schizophrenia using the California Verbal Learning Test (CVLT-II) as a measure of learning potential, the static version of the WCST, and a Quality of Life Scale (QLS). They found 2-month test-retest reliability estimates to be moderate for all three indices of learning potential: learner group categories, PPD scores, and regression residuals. Further, learner group categorization was negatively associated with static WCST scores (percentage of errors and perseverative errors) and positively with the intake QLS score. Fiszdon and Johannesen concluded that the categorical classification index and post-training performance score were reliable and valid methods for learning potential research. Overall, these results support categorical rather than dimensional classification as a more stable and valid measurement of learning potential.

Validity of Learning Potential

As interest in understanding learning potential in people with SMI has grown, so has the need to validate the construct. Additional studies have provided evidence for the validity of the learning potential construct. Wiedl et al. (2001b) examined whether a priori classification of participants according to learner status (see Schottke et al., 1993) could be validated using cluster analyses and whether these groups would demonstrate distinctive performance on measures of attention. A sample of 49 inpatient participants with schizophrenia completed a Degraded Stimulus Continuous Performance Test (DS-CPT; objective) and the Test of Attentional Style (TAS; subjective). Results of the cluster analysis of WCST trial one scores revealed three distinct clusters, supporting classification into three learner groups: high scorers, learners and non-learners. No participants declined in performance from trial one to trial three in this sample. Results from group comparisons on attentional characteristics demonstrated significant differences such that high scorers outperformed non-learners on both discriminant sensitivity (correct responses on the DS-CPT) and response criterion (false alarms on the DS-CPT). All three learner groups significantly differed from each other on the distractibility subscale of the TAS. Learner groups did not statistically differ in age, education, illness duration or intelligence providing evidence of discriminant validity. Wiedl et al. noted that differences in performance between groups could also be related to proficiency in rehabilitation training; differences that would not be captured using static neurocognitive measures.

Kurtz and Wexler (2006) also investigated whether a priori categorical classification of learning potential in people with schizophrenia using the WCST could be validated using other measures of executive functioning, and if so, whether these groups would also demonstrate distinct patterns of executive functioning. A total of 54 participants with schizophrenia/schizoaffective disorder initially completed a standard administration of the WCST (trial 1). Based on trial one performance, participants were classified as either cognitively intact (five or greater categories completed; $N = 28$) or impaired (less than five categories completed; *N* = 26). Impaired participants were further subdivided into strong learners (*N* = 13) or poor learners (*N* = 13) based on a median split of WCST trial three performance.

Kurtz and Wexler (2006) found that significant differences in verbal memory performance across all three learner groups (Intact > Strong Learners > Poor Learners) supported a categorical approach using the WCST. Participants categorized as 'intact" performed significantly better in all cognitive domains (working memory, attention, and verbal and logical memory) and were also higher in functional capacity than both learner groups, suggesting a stronger potential for rehabilitation outcome. Additionally, strong learners outperformed poor learners on tests of attention and verbal memory.

Similarly, Rempfer et al. (2006) examined the cognitive characteristics associated with learning potential in people with SMI. Sixty people with schizophrenia, schizoaffective disorder, bipolar disorder and major depression completed a test-train-test (dynamic) version of the 64-card WCST. Participants were categorized as high achievers, learners or non-retainers based on their pre-test WCST performance as previously established in the literature (Schottke et al., 1993; Wiedl, 1999). Rempfer et al., (2006) found that high achievers had significantly greater performance on measures of attention, processing speed, and working memory compared to non-retainers. However, learners' performance was not significantly different from either group on these cognitive domains of attention, processing speed, and working memory. In the area of verbal memory performance, both learners and high achievers demonstrated significantly higher performance on tasks of verbal memory than non-retainers. These results indicate that cognitive performance does differ among learner groups, however the precise nature and strength of these differences remains unclear.

Learning potential also shows promise for clinical applicability in the SMI population due to its encouraging relationships with positive outcomes (predictive validity). Wiedl et al. (2001a) found that learning potential, identified by dynamic performance on the WCST, was a better predictor of medication adherence following a psycho-educational intervention than static WCST scores. Learning potential has also been shown to be an indicator of readiness for psychosocial rehabilitation (Fiszdon et al., 2006; Wiedl, 1999), vocational rehabilitation (Sergi et al., 2005; Watzke et al., 2009), and skill acquisition (Rempfer, Brown & Hamera, 2011; Watzke et al., 2008). Overall, the results of these studies provide construct validity evidence for learning potential captured using dynamic assessment methods. Further, it appears that attention and working memory skills may facilitate learning in this population, and thus, these cognitive domains may be targets of interest in developing/assessing psychosocial rehabilitation potential.

Construct Validity of Learning Potential

Wiedl et al. (2004) investigated whether training on the WCST would alter the construct validity of the test by examining relationships between pre-post-training performance and measures of verbal memory (using the Auditory Verbal learning Test, AVLT; German version), general intelligence (using the Test of Word Power, TWP), and clinical symptoms (using the Scale for the Assessment of Negative Symptoms, SANS; and the Brief Psychiatric Rating Scale, BPRS). It was predicted that problem solving (measured with the Tower of Hanoi; TOH) and selective attention (using the Stroop Color Word Interference Test) would show differential patterns of association between trials one and three of the WCST.

Results of Wiedl et al. (2004) indeed supported the notion that post-training WCST performance represents a different construct than what is captured by the static WCST. Evidence of the learning potential construct was demonstrated by the observation that problem solving and verbal memory were significantly associated with trial three WCST performance, however not trial one performance. In addition, the strength of the correlational relationship between problem solving, verbal memory, and learning potential significantly differed across trials. Interestingly, clinical symptoms were not related to any aspect of dynamic WCST performance.

Wiedl et al. (2004) further speculated that the use of contextual information and secondary verbal memory may be components of executive functioning that possibly mediate performance in rehabilitation programs. If so, the dynamic version of the WCST may capture these components more effectively than the static version, thereby increasing its value as a predictor of rehabilitation response. Wiedl et al. concluded that the dynamic version of the WCST measures a separate construct than the static version, and that its ability to predict functional outcomes lies within the cognitive domains of verbal memory and learning potential.

Purpose

Because learner group classification has demonstrated variable relationships with positive psychosocial outcomes, it is important to deepen our understanding of specific differences between learner groups. Building upon the methods of Wiedl et al. (2004), the purpose of this study was to investigate the change, from pre- to post-training, in the relationships between WCST performance and other cognitive domains. Previous research has provided evidence that learning potential is related to working memory and attention, but the precise nature of this relationship remains unclear. As a follow up to Wiedl et al. (2004), this study aimed to investigate the degree to which the specific cognitive domains of working memory and attention are related to learning potential.

The first aim of this study was to investigate associations between neurocognitive characteristics and learning potential performance in people with SMI. It was hypothesized that learning potential, as measured by the WCST, would be more strongly associated with attention and working memory than with other areas of cognitive performance. A second aim of this study was to examine the strength of associations between cognition and WCST performance pre- and post-training. It was hypothesized that attention and working memory skills would show stronger relationships with trial three of the WCST (i.e. learning potential) than with trial one of the WCST (static) providing evidence of a stronger influence of attention and working memory on the learning measure than the standard WCST. A third aim of this study was to investigate whether the relative contribution of attention and working memory skills to learning potential performance could predict learner group membership. It was specifically hypothesized that attention and working memory performance would emerge as a stronger predictor of learner status than other cognitive domains.

Currently, not much is known or discussed in the learning potential literature about the relative influence of working memory and attention skills on learning potential compared with other areas of cognitive functioning. Wiedl et al. (2004) investigated changes in the construct validity of learning potential in people with schizophrenia. The current study builds upon this work with an increased sample size, expansion of participants to the broader population of people with SMI, and an increased number of standardized neurocognitive measures to compare to the dynamic WCST. Due to the promising findings between learning potential and rehabilitation outcomes, the results of this study may have important clinical and research implications for furthering our understanding of the contribution of specific areas of executive functioning that influence learning potential and possibly improving/modifying interventions and rehabilitation outcome potentials for people with SMI.

CHAPTER 3

METHODOLOGY

Participants and Procedure

A total of 192 participants with serious mental illness, ages 18-65 were included in data analysis for the present study. This study was a secondary analysis of data collected in three prior studies conducted between the years of 2006-2012. Participants were recruited via case management staff at 4 local and regional community mental health centers in the Kansas City area that offered intensive outpatient treatment. All participants provided informed consent. Testing was administered in a private room at the respective community health facility. All diagnoses were confirmed using the Structured Clinical Interview for the DSM-IV (SCID; First, Spitzer, Gibbon, & Williams, 1996). Exclusionary criteria included known neurological disease, developmental disability, significant sensory/physical impairment that would affect task performance (e.g. blindness), or reported substance abuse/dependence in the prior 30 days. All study procedures received institutional review board approval. Further clinical and demographic data are given in table 2.

Table 2. Demographic Characteristics.

N = 192	Mean (*SD*)	N (%)
Diagnostic Category		
• Schizophrenia		77 (40.1%)
• Schizoaffective Disorder		60 (31.3%)
• Major Depressive Disorder		29 (15.1%)
• Bipolar Disorder		26 (13.5%)
Age	42.85 (*9.77*)	
Gender		
• Female		105 (55%)
• Male		87 (45%)
Race		
• African American		77 (40.1%)
• Caucasian		94 (49%)
• Multi-Racial		21 (10.9%)
Marital Status		
• Never married		101 (52.6%)
• Divorced/Widowed/Separated		70 (36.5%)
• Married/Living together		21 (10.9%)
Education		
• Less than high school		46 (23.9%)
• High school/GED		63 (32.8%)
• Post high school/no college		7 (3.6%)
• Some college		61 (31.8%)
• College 4 year degree		9 (4.7%)
• College beyond 4 year degree		6 (3.1%)
Living Situation		
• Lives independently		126 (65.6%)
• Lives with relatives		38 (19.7%)
• Supervised care housing		16 (8.3%)
• Long term care facility		1 (0.5%)
• Other		11 (5.9%)
Psychiatric Symptoms		
• BPRS-E (N=61)	33.84 (*10.05*)	
• SANS (N=90)	30.51 (*14.84*)	
• SAPS (N=90)	32.40 (*17.53*)	

NOTE: BPRS-E=Brief psychiatric Rating Scale-Expanded; SANS=Scale for the Assessment of Negative Symptoms; SAPS=Scale for the Assessment of Positive Symptoms.

Data

As stated above, the present study was a secondary analysis of existing data sets. The first dataset (A) contained information from 40 participants with SMI (schizophrenia/schizoaffective = 25, affective disorder = 15). There were 20 males and 20 females with an average age of 45.5 (*sd*=10.41). Twenty-five (62.5%) reported race as African American, 11 (27.5%) Caucasian and 4 (10%) reported being multi-racial. Education included 15 people that reported less than high school (37.5%), 13 that reported completing high school (32.5%), 11 people that reported post-high school technical/some college (27.5%) and 1 person who reported completion of a bachelor's degree (2.5%). In response to the training intervention, 14 were identified as high performers, 13 as learners and 13 as non-retainers.

The second dataset (B) contained information from 91 participants with schizophrenia/schizoaffective disorder. There were 48 males and 43 females with an average age of 41.5 (*sd*=9.02). Forty-seven (51.6%) reported race as African American, 34 (37.4%) Caucasian, 3 Hispanic (3.3%) and 7 (7.7%) reported being multi-racial. Education included 24 people that reported less than high school (26.4%), 25 that reported completing high school (27.5%), 34 people that reported post-high school technical/some college (37.4%) and 8 people who reported completion of a bachelor's degree and beyond (8.8%). In response to the training intervention, 22 were identified as high performers, 37 as learners and 32 as non-retainers.

The third dataset (C) contained information from 61 participants with SMI (schizophrenia/ schizoaffective disorder=21, affective disorder=40). There were 19 males and 42 females with an average age of 42.98 (*sd*=10.18). Five (8.2%) reported race as African American, 49 (80.3%) Caucasian, 1 Hispanic (1.6%) and 6 (9.7%) reported being multi-racial. Education included 7 people that reported less than high school (11.5%), 25 that reported completing high school (41%), 23 people that reported post-high school technical/some college (37.7%) and 6 people who reported completion of a bachelor's degree and beyond (9.8%). In response to the training intervention, 21 were identified as high performers, 19 as learners and 21 as non-retainers. Data analyzed for this study included demographic information, a WCST learning potential assessment, and a battery of standard neurocognitive measures. Descriptive information and mean cognitive values are summarized in Table 3.

Measures

Wisconsin Card Sorting Test

The WCST (Heaton et al., 1993) is widely used as a measure of executive functioning. Test-takers are asked to match 64 stimulus cards (64-card version) to one of four key cards picturing different geometric designs that vary in color and number of items on the key card. There are three possible match options: color, shape (form) or number. Test takers are not informed of the sorting rules, however are given immediate "correct" or "incorrect" feedback after each attempted match as recommended by Heaton et al. (1993). After a certain number of consecutively correct matches, the sorting rule changes unbeknownst to the test taker. The standard administration of the WCST (64 card version) produces measures of correct responses, error responses, and conceptual level responses. Dynamic assessment using the WCST is administered in three successive trials. The first and third trials are administered in a standard format. The second trial includes a teaching component, which incorporates direct feedback after each trial and explanation of the sorting principles.

This study utilized a dynamic administration (test-train-test paradigm) as outlined by Green et al. (1992) and Wiedl et al. (2001b). Trials one (pre-test) and three (post-test) follow the standard administration procedure, while trial two involves expanded explanation and instruction on the test using card-by-card feedback (e.g. Green et al., 1992). Participants are informed of the matching rules after completing trial one. During the trial two training, participants are also informed whether their response was correct or incorrect and why (e.g., “Correct, you sorted by color and color is the correct category” or “Incorrect, this card matches by number and color is the correct category”). Participants are also informed of rule changes (e.g., “After a certain number of correct sorts in a row the rule will change. You will no longer sort for color, but for shape or number”). Trial one pre-test scores represent static executive functioning, however trial three post-test scores represent dynamic learning potential.

Learner status was determined using methods outlined by Schottke et al. (1993). For the purposes of this study, the variables of interest were the total number of correct sorts (TC; 64-card version) and perseverative errors (PE; sorting errors made according to a previous sorting rule that is not being reinforced) from trials one and three of the WCST.

California Verbal Learning Test

The CVLT-II (Delis, Kramer, Kaplan, & Ober, 2000) is a measure of auditory-verbal working memory. Participants are read a list of 16 words and are asked to recall these words in any order. This protocol was repeated three times, however for the purposes of this study, only the number of words recalled from block one was used as the variable of interest. Block one was used exclusively as the variable of interest as repeated recall may capture an inherent learning component.

D2 Test of Attention

The D2 (Brickenkamp & Zillmer, 1998) is a timed letter cancellation task that measures processing speed and selective attention. Participants are asked to select a single letter ‘d’ with two dashes and make a single line through the letter. Letters other than ‘d’ or a ‘d’ with other than two dashes should not be marked. Participants are given one practice line and instructed to work as quickly as they can without making mistakes. Participants are presented with 14 lines of competing stimuli. After 20 seconds, they are instructed to stop and move to the next line. Participants are scored based on total number of correct cancellations and number of cancelled foils. The variable of interest for this study was concentration performance, which provides an index of speed and accuracy.

Controlled Oral Word Association Test (FAS)

The Controlled Oral Word Association Test (COWAT; FAS version; Benton & Hamsher, 1976) is a measure of verbal fluency that asks participants to generate as many words as possible that begin with the target letter (F, A, and S) in one minute over three consecutive trials. Participants are instructed not to use proper nouns (e.g. France, Stephanie), numbers (e.g. four, seven), or the same word with a different ending (e.g. boat, boats, boating). The summative score of words produced for all three trials was used as the variable of interest.

Trail Making Tests A & B

The Trail Making Test (Reitan, 1992) is a visual scanning test that measures cognitive flexibility and processing speed. Trails A requires participants to connect a group of consecutive numbers and measures processing speed. Trails B requires participants to alternately connect numbers and letters in order (1-A-2-B-3-C, etc.), and measures set shifting ability (cognitive flexibility). Participants are redirected if an error is made during administration. The time in seconds (separately) to complete Trails A and Trails B were used as the variables of interest.

Months Ordering Task

In this working memory task, participants listen to a series of months and are instructed to repeat them back in order as they would be found on a calendar. The task continues with increasingly larger lists of months being read, until the participant no longer repeats them correctly. The highest level at which the participant's recall is correct is his or her span (Almor et al., 1999).

Digits Forward and Backward

In this subtest of the Wechsler Adult Intelligence Scale-III (WAIS-III; Wechsler, 1997) participants repeat a set of orally presented string of numbers at the rate of one per second. In Digits Forwards, participants repeat the digits, exactly as spoken. In Digits Backward, participants reverse the order of the spoken digits. Score is determined by number of digits recalled in the longest span. The test is discontinued after two consecutive failed attempts at digit retrieval in the same span length.

Letter-Number Sequencing

Another subset of the WAIS-III (Wechsler, 1997), participants are asked to listen to strings of alternating letters and numbers of increasing length and then 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.

Scale for the Assessment of Positive and Negative Symptoms

The Scale for the Assessment of Positive Symptoms (SAPS; Andreason, 1984) and Scale for the Assessment of Negative Symptoms (SANS; Andreason, 1983) are rating scales designed to measure positive and negative symptoms (respectively) in people with schizophrenia. The SAPS measures four domains of positive symptoms including hallucinations, delusions, bizarre behavior and disordered thinking. The SANS measures five domains of negative symptoms including affective flattening, alogia, avolition (apathy), anhedonia (asociality) and attention. Both are administered via clinical interview and rated on a 6 point Likert type scale ranging from “absent” to “severe”. Summative scores of the SANS and SAPS indicate current levels of psychopathology and for the purposes of this study, were transformed into Z scores in order to merge with other symptom measures (Lyne, Kinsells, & O’Donoghue, 2012).

Brief Psychiatric Rating Scale- Expanded

The Brief Psychiatric Rating Scale-Expanded (BPRS–E; Lukoff, Nuechterlein, & Ventura, 1986) is also a rapid assessment of psychopathology symptoms. The BPRS-E is administered via clinical interview and responses are scored on a 7 point Likert type scale ranging from “not present” to “extremely severe”. Answers are scored from 1 to 7 for each item and a summative score indicates current levels of psychopathology symptoms within the last two weeks. The BPRS can be divided into positive (BPRS-PS) and negative (BPRS-WR) subscales. Positive psychotic symptoms measured by the BPRS-PS include hallucinations, unusual thought content, suspiciousness, and conceptual disorganization (Lyne et al., 2012; Ventura, Nuechterlein, Subotnik, Gutkind, & Gilbert, 2000). The BPRS-WR is comprised of withdrawal-retardation factors and measures negative symptoms including blunted affect, emotional withdrawal, and motor retardation (Lyne et al., 2012; Welham, Stedman, & Clair, 1999). For the purposes of this study, summative scores of positive and negative symptoms were transformed into Z scores in order to merge with other symptom measures (Lyne et al., 2012).

Statistical Analyses

In order to address the first aim of the study, Steiger’s Z comparisons of bivariate correlations were examined in order to identify the strength of relationships between neurocognitive measures and trial three of the WCST post-training (learning potential construct). It was predicted that measures of attention and working memory would show stronger correlations with trial three of the WCST than would other measures of cognition. For these analyses, a standard alpha of 0.05 was utilized as the Meng’s T-test (based on Steiger’s Z distribution) is inherently conservative (Meng, Rosenthal, & Rubin, 1992; Wilcox & Tian, 2008; for the calculation algorithm, see Steiger 1980). Due to the high number of comparisons, a Bonferroni correction was used for the bivariate correlations resulting in a criteria alpha of 0.001.

To investigate the second aim, Steiger's Z comparisons of bivariate correlations were used in order to investigate the relative influence of the cognitive measures on learning (Steiger, 1980). It was predicted that associations between attention, working memory and trial three of the WCST (post-training) would be significantly greater than their association with trial one of the WCST (pre-training), suggesting that within the learning potential construct, attention and working memory skills are the key components being measured. For these analyses, a standard alpha of 0.05 was utilized as the Meng's T-test (based on Steiger's Z distribution) is inherently conservative (Meng, Rosenthal, & Rubin, 1992; Wilcox & Tian, 2008).

Last, in order to examine the third aim, hierarchical regression models were used in order to determine if learning potential (as measured by the total score on the WCST after training; TC T3) could be predicted using cognitive and demographic information. It was expected that working memory and attentions scores would explain a greater amount of variance (significant R^2 change) in the prediction of learning potential than other measures of cognition.

CHAPTER 4

RESULTS

Description of the Sample

Means and standard deviations for WCST scores in the three learner categories are listed in table 3. All pairwise comparisons for learners across performance times and for number of correct sorts (TC) and perseverative errors (PE) were significant ($p<0.001$). Participants had significantly improved performance in T2 and although T3 performance was lower, it was still significantly higher than performance in T1. The average gain score (WCST TC T3 – T1) for the sample was 10.89 (*10.78*) correct sorts, modal score was 8($N=11$). Learners gained an average of 22.52 (*6.57*) correct sorts with a modal score of 19($N=8$), whereas non-retainers gained an average of 4.35 (*6.78*) correct sorts after training intervention with a modal score of 13($N=7$). Although gain scores for the overall sample and non-retainers were normally distributed, gain scores for learners were positively skewed (0.996). As this was an expected distribution, no corrections were made. There were no significant group differences between diagnostic groups (psychotic spectrum disorder vs. mood disorder) on educational background, independent living status, overall severity of psychopathy or cognitive performance, including dynamic performance on the WCST. Diagnostically, the psychotic spectrum group included more males, African Americans, and reported a higher rate of never being married or being divorced compared to the sample comprised of people with mood disorders.

Table 3. Clinical and Neurocognitive Variables.

Total N = 192	Cognitive Domain	Mean (*SD*)	N (%)
Original Study			
• A			61 (31.8%)
• B			91 (47.4%)
• C			40 (20.8%)
WCST			
• TC-T1		35.80 *(11.61)*	
• PE-T1		17.05 *(11.22)*	
• TC-T2		57.55 *(6.99)*	
• PE-T2		2.12 *(4.76)*	
• TC-T3		46.48 *(10.77)*	
• PE-T3		9.75 *(8.76)*	
• Gain (T3-T1)		10.89 *(10.78)*	
• Learner Status			
o High performer			57 (29.7%)
o Learner			69 (35.9%)
o Non-Retainer			66 (34.4%)
Neurocognitive Measures/Domain			
• D2	Attention	100.70 (*43.20*)	
• COWAT	Verbal Fluency	27.78 (*10.33*)	
• Trails A	Processing Speed	42.56 (*19.40*)	
• Trails B	Set-Shifting	29.67 (*69.67*)	
• CVLT-II (Block 1)	Verbal Memory	5.43 *(2.13)*	
• Digits Forward	Immediate Memory	8.12 (*2.00*)	
• Digits Backward	Working Memory	4.49 (*1.99*)	
• Months Ordering	Working Memory	7.45 (*3.47*)	
• Letter-Number Sequencing	Working Memory	7.08 (*2.99*)	

NOTE: WCST=Wisconsin Card Sorting Test; T1=pre-training score; T3=post-training score; TC=total items correct; PE=perseverative errors; Gain score indicates the difference in total items correct between times one and three; CVLT-II=California Verbal Learning Test; COWAT=California Oral Word Association Test (FAS version); Trails A&B scores represent time in seconds.

Aim 1: Relationships between learning potential and neurocognitive measures

The first aim of this study was to investigate the relationship between neurocognitive characteristics and learning potential performance in people with SMI. As shown in Table 4, all measured areas of cognition were statistically significantly related to WCST T3 performance (learning potential). It was predicted that learning potential would show the strongest relationships with measures of attention and working memory. Investigation of the correlational analyses revealed that large and moderate effect sizes were indeed seen in the variables conceptualized to capture working memory and attention: Letter-number sequencing ($r=0.512$, $p<0.01$), Months ordering ($r=0.447$, $p<0.01$), Digits backward ($r=0.414$, $p<0.01$), Trail making tests A ($r=-0.410$, $p<0.01$) and B ($r=-0.394$, $p<0.01$) and the D2 Test of Attention ($r=0.392$, $p<0.01$). Further, investigation into the differences of the correlations using Steiger's Z comparisons revealed that measures of working memory shared a significantly stronger relationship with learning potential compared with other measures of cognition. Digits Backward was more strongly related to learning potential (WCST TC T3) than Trails A (Z=6.36, df 147; p<0.001) or Trails B (Z=5.66, df 137; p<0.001). The Months Ordering Test was more strongly related to learning potential (WCST TC T3) than the COWAT (Z=2.16, df 148; p<0.05), Trails A (Z=6.70, df 149; p<0.001), Trails B (Z=6.00, df 139; p<0.001), or the CVLT-II (Z=2.15, df 84; p<0.05). The Letter-Number Sequencing Test demonstrated a significantly stronger relationship with learning potential (WCST TC T3) than did the COWAT (Z=2.79, df 128; p<0.01), Trails A (Z=6.85, df 128; p<0.001), Trails B (Z=6.15, df 120; p<0.001), CVLT-II (Z=3.45, df 124; p<0.01), or Digits Forward (Z=2.18, df 88; p<0.05). Contrary to prediction, attention was not more strongly related to learning potential compared to any other area of cognition. Overall, learning potential is associated with many areas of neurocognitive functioning, however attention and working memory performance measures show the strongest relationships with learning potential performance. A correlational matrix of all cognitive variables is presented in table 4.

Aim 2: Working memory, attention and learning potential

The second aim of this study was to examine the strength of associations between cognition and WCST performance pre- and post-training. It was predicted that measures of working memory and attention would be more strongly associated with WCST T3 (learning potential) than T1. Comparison of the correlation coefficients using Steiger's *Z* distributions revealed that some variables were differentially associated with WCST TC T1 compared to T3. See Table 4.

For number of correct sorts (WCST TC), several measures of working memory (Digits Backward, Months Ordering, and Letter-Number Sequencing) were more strongly related to T3 post training (learning potential) than T1 pre-training performance. The CVLT-II, a measure of verbal memory, also demonstrated a significantly greater relationship with WCST TC T3 compared to T1. It was additionally predicted that the D2 and Trail Making Test B, as measures conceptualized to capture attention and working memory respectively, would be more strongly related to WCST T3 performance (learning potential) than T1. This prediction was not supported. Investigated differences in perseveration (WCST PE) indicated that only Letter-Number Sequencing (working memory) and the CVLT-II (verbal memory) significantly differed from WCST T1 and T3 performance. These results are summarized in table 4.

Table 4. Pearson correlations and Steiger's Z comparisons between WCST pre- and post-training scores (T1/T3) and other neurocognitive variables.

Variables	N	TC-T1	TC-T3	PE-T1	PE-T3
D2 Attention	175	**0.316*** **	**0.392*** **	**-0.248*** **	**-0.313*** **
		Z=1.11; n.s.		Z=0.92 n.s.	
COWAT Verbal Fluency	191	**0.323*** **	**0.250*** **	**-0.283*** **	**-0.238*** **
		Z=1.08; n.s.		Z=0.66; n.s.	
Trails A Processing Speed	192	**-0.332*** **	**-0.410*** **	**0.269*** **	**0.350*** **
		Z=1.22; n.s.		Z=-1.21; n.s.	
Trails B Set Shifting	181	**-0.358*** **	**-0.394*** **	**0.336*** **	**0.306*** **
		Z=0.54; n.s.		Z=0.44; n.s.	
CVLT II Block 1 Immediate Memory	127	0.000	0.197	0.014	-0.158
		Z=2.27; n.s.		**Z=3.39; p<0.01**	
Digits F Immediate Memory	152	0.187	**0.310*** **	-0.176	**-0.288** **
		Z=1.61; n.s.		Z=1.45; n.s.	
Digits B Working Memory	150	**0.275*** **	**0.414*** **	**-0.316*** **	**-0.346*** **
		Z=1.88; p<0.05		Z=0.40; n.s.	
Months Ordering Working Memory	149	**0.284*** **	**0.447*** **	-0.225	**-0.342*** **
		Z=2.24; p<0.05		Z=1.52; n.s.	
LNS Working Memory	131	**0.352*** **	**0.512*** **	**-0.295*** **	**-0.472*** **
		Z=2.13; p<0.05		**Z=2.27; p<0.05**	

***p<.001. NOTE: WCST=Wisconsin Card Sorting Test; TC=total items correct; PE=perseverative error; T1=pre-training score; T3=post-training score; D2=D2 Test of Attention; CVLT-II=California Verbal Learning Test II; COWAT=California Oral Word Association Test (FAS version); Trail Making Test A&B scores represent time in seconds; Digits F-Digits Forward; Digits B-Digits Backward; LNS=Letter-Number Sequencing.

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Aim 3: Hierarchical regression

The third aim of this study was to investigate the relative contribution of attention and working memory skills to predict learner status (WCST TC T3). For the purposes of these analyses, a composite working memory score was derived from the summative standardized scores of the following measures: Trail Making Test B, Months Ordering Task, Digits Backward and the Letter-Number Sequencing score. It was hypothesized that attention and working memory performance would emerge as a stronger predictor of learner status than other cognitive domains. The full hypothesized model included age and education entered at step one; CVLT-II (verbal memory), COWAT (verbal fluency), Digits Forward (immediate memory) and Trails A (processing speed) scores in step two; the D2 (attention) score in step three; and the Working Memory Composite Score in the fourth and final step. Results were examined for overall model fit (R^2 change) and individual variable contribution at each step of the model. Overall, working memory contributed the greatest amount of explained variance to the prediction of learning potential (WCST TC T3) scores after controlling for age, education and other areas of neurocognitive functioning. Results are summarized in Table 5.

Table 5. Summary of R^2 Changes at Each Step in the Hierarchical Regression.

	B (SE)	□	R^2_Δ	F_Δ
Step 1				
• Constant	53.15 (5.84)			
• Age	-0.348 (0.13)	-0.326**		
• Education	1.55 (0.80)	0.235	0.109	4.14**
Step 2				
• Constant	44.72 (7.51)			
• Age	-0.338 (0.13)	-0.317*		
• Education	1.01 (0.81)	0.15		
• CVLT-II	0.79 (0.51)	0.18		
• COWAT	-0.02 (0.09)	-0.02		
• Digits Forward	1.00 (0.51)	0.23		
• Trails A	-0.03 (0.06)	-0.06	0.116	2.40
Step 3				
• Constant	39.35 (8.09)			
• Age	-0.25 (0.14)	-0.23		
• Education	0.75 (0.82)	0.11		
• CVLT-II	0.67 (0.51)	0.15		
• COWAT	-0.04 (0.09)	-0.04		
• Digits Forward	0.70 (0.54)	0.16		
• Trails A	-0.00 (0.06)	-0.00		
• D2 Test of Attention	0.05 (0.03)	0.23	0.032	2.74
Step 4				
• Constant	46.08 (8.3)			
• Age	-0.13 (0.14)	-0.13		
• Education	0.25 (0.82)	0.03		
• CVLT-II	0.42 (0.50)	0.10		
• COWAT	-0.05 (0.09)	-0.06		
• Digits Forward	0.11 (0.57)	0.02		
• Trails A	-0.02 (0.06)	-0.04		
• D2 Test of Attention	0.04 (0.03)	0.18		
• WMC	1.46 (0.62)	0.33*	0.060	5.46*

NOTE: One predictor entered in each step of the model in a user-determined sequence. *p is significant at the 0.05 level (two-tailed), **p is significant at the 0.01 level (two-tailed), ***p is significant at the 0.001 level (two-tailed).

Exploratory Analyses

Exploratory investigation into possible differences according to learner categorization using bivariate correlational analyses revealed significant relationships with age, education and independent living situation. Age was associated with greater PE on WCST T1 (Pearson $r=0.219, p<0.01$). Living situation was related with WCST performance such that living independently was associated with greater TC T3 (Spearman $r=0.210, p<0.01$) and less PE T1 (Spearman $r=-0.189, p<0.01$). Education was associated with greater WCST TC T3 (Spearman $r=0.229, p<0.01$), and less PE T3 (Spearman $r=-0.228, p<0.01$). Education was not related to WCST TC on T1

Analyses of the relationship between WCST performance and psychiatric symptoms revealed that overall symptom severity as measured with the BPRS-E was only associated with PE on T1 (Pearson $r=0.270, p<0.05$). Positive psychiatric symptoms measured using the SAPS were associated with PE T1 (Pearson $r=-0.274, p<0.01$). Negative symptoms measured using the SANS were associated with TC on T3 (Pearson $r=-0.223, p<0.05$).

CHAPTER 5

DISCUSSION

The purpose of this study was to investigate the change, from pre- to post-training, in the relationships between WCST performance and other cognitive domains. Conceptualized to capture learning potential, performance on the dynamic WCST was hypothesized to show differential relationships with various neurocognitive domains. Working memory and attention were predicted to share the strongest relationship with learning potential. By comparing the strength of relationships with these various neurocognitive domains and WCST performance before and after training, this study intended to investigate the degree to which the specific cognitive domains of working memory and attention were related to learning potential. Analysis of these results showed that the relationship between learning potential and neurocognitive performance did indeed differ before and after training on the WCST.

When examined individually, some variables did not change in their relationship between WCST T1 (static) and T3 (dynamic) performance; however in contrast, significant differences in correlational relationships before and after WCST training were observed primarily in tasks of working memory. The pattern of correlations between neurocognitive variables and WCST dynamic performance showed a stronger relationship with tasks associated with working memory. Specifically, complex tasks of working memory that not only require immediate recall of information, but also require a manipulation of that information (such as Letter Number Sequencing, Months Ordering or Digits Backward), demonstrated the strongest relationships with learning potential performance. These types of tasks are conceptualized to capture more complex working memory performance given that the tasks require comparison of new information against existing information in long term memory storage (semantic or procedural), while being held in short term memory. Hierarchical regression analyses also revealed that tasks of working memory contributed the greatest amount of explained variance in learning potential, above other areas of cognition.

Significant changes pre- and post-intervention on the WCST were also seen for the CVLT-II. It may be that short term memory storage as measured with the CVLT-II is required for more complex working memory tasks. Similarly, although it was expected that attentional skills would be differentially related to WCST performance, it is likely that dedicated attention skills are required for both pre- and post-training aspects of the WCST, thus explaining the lack of significant differences between pre-and post-intervention WCST performance.

Overall symptom severity and positive symptoms, the two symptomatic areas most frequently targeted for bio-psycho intervention, were only related to WCST pre-training performance such that higher severity or frequency of positive symptoms was associated with greater perseveration. Negative symptoms appeared to influence learning potential performance only for the number of correct sorts. This is consistent with literature demonstrating a strong relationship between poor neurocognitive performance, specifically in the areas of attention and working memory, and negative symptoms (Hofer et al., 2011; Zaytseva et al., 2012). However other research has demonstrated that for people with schizophrenia, negative symptoms were not predictive of rehabilitation outcome (Bark et al., 2003).

Not surprisingly, living independently was also associated with better performance both pre- and post-intervention on the WCST both in greater number of correct sorts and less perseverative errors. People who live independently may have greater complex working memory capabilities, which allow them to manage multiple aspects of independent living, whereas someone who struggles with deficits in this area may need a higher level of care in order to effectively manage activities of daily living. Higher levels of education were also associated with improvements in number of correct sorts (TC) and less perseverative errors (PE) in T3. Fiszdon et al. (2006) found that education moderated cognitive training proficiency such that among learners, those with post-secondary education demonstrated higher cognitive performance after training compared with learners with lower education levels. There is also evidence in the cognitive remediation literature that frequent activation of these systems may improve working memory and thus, learning potential performance (Sanchez et al., 2014; Wykes et al., 2007b).

Just as it has been established that cognitive deficits are a key component of serious mental illness, so too has it been established that there are neurocognitive differences among learner groups (Green et al., 1990; Kurtz & Wexler, 2006; Rempfer et al., 2006). In 2004, Wiedl et al. suggested that working memory functioning could possibly mediate participants' response to training intervention on the WCST. Wiedl specifically investigated whether dynamic testing actually measured a separate construct of executive functioning compared to static testing. The results presented here build upon this earlier work by demonstrating not only a differential relationship between static and dynamic performance, but also provide evidence of the relative influence of working memory, above other areas of cognition, on learning potential performance. These results also add to the literature by deepening our understanding of the mechanism by which executive functioning plays a role in learning. Wiedl demonstrated that learning potential performance, as measured through dynamic testing, significantly increased the amount of explained variance in the prediction of positive functional outcomes. As such, this area of research could suggest an important utility for measuring learning potential in individuals with mental illness in order to predict intervention response.

Applicability

Cognitive rehabilitation focuses on improving cognition in people who have suffered a decline in neuropsychological functioning (Medalia & Richardson, 2005). Interest in cognitive remediation strategies began in the early 1900's and has become a significant area of focus within the schizophrenia and serious mental illness literature (Bellack, Gold & Buchanan, 1999; McGurk, Twamley, Sitzer, McHugo &Mueser, 2007; Meichenbaum & Cameron, 1973; Twamley, Jeste & Bellack, 2003; Wykes et al., 2011). Research in this area typically focuses on community outcomes, such as the ability to work, go to school or psychosocial skill acquisition. Green et al., (2000) found that 20%-60% of positive outcomes could be predicted using composite measures of cognition. This means that cognitive performance can serve as an indicator of how well a person will do in response to interventions designed to improve functional outcomes. By measuring learning potential performance, intervention response can be further enhanced by identifying target areas for remediation, such as working memory.

As such, this study also has important clinical application. Working memory deficits persist despite psychopharmacological interventions which control or reduce symptom severity. Cognitive remediation strategies could be enhanced by considering a person's cognitive capacity for learning. Working memory supports learning, which is a goal of clinical intervention (i.e. learning new skills). Because working memory limitations could interfere with learning, clinicians may need to develop interventions that compensate for or reduce working memory load, thus improving intervention efficacy. Rehabilitation interventions can be strengthened by attempting to remediate working memory skills by assisting clients in developing a better ability to retain information using cognitive strategies, and/or the use of repetition with skill development (Twamley et al., 2003). For example, Bell, Bryson, and Wexler (2003) found that in people with schizophrenia, neurocognitive enhancement therapy in combination with work therapy significantly increased working memory capacity and response to intervention, regardless of initial symptom severity. Furthermore, there was no measureable decline in working memory ability at one year post intervention follow up, demonstrating the durability of this effect. Cognitive remediation therapy has been shown to be effective in both children and adults with a range of psychological disorders including schizophrenia, depression, eating disorders, and cognitive decline associated with substance use primarily through the use of repetition strategies (Elgamal, McKinnon, Ramakrishnan, Joffe, & MacQueen 2007; Sofuoglu, DeVito, Waters, & Carroll, 2013; Tchanturia, Davies, & Campbell 2007; Wykes et al., 2007a).

Limitations and Future Research

The present study must be viewed within the context of several limitations. Learning potential is presumed to be a latent construct and is inferred through improvement after training on a particular task, such as the WCST. Thus, learning potential is dependent on the effectiveness of the intervention. In this study the intervention was training on the WCST. In fact, an overall limitation in learning potential research is that it's almost exclusively focused on this one measure. The results presented here may indicate a reliance on working memory for successful improvement on the WCST rather than being a requisite feature of learning potential. Although statistical analyses confirmed that the intervention as a whole was effective, people may have differed in their motivation and attention levels. Future studies should look closely at factors that augment or interfere with effectiveness of cognitive interventions. Exploration of other possible methods of measuring learning potential is also recommended, such as expanding measures that measure learning potential and investigating continuous, rather than categorical, methods of capturing learning potential. Increased sample sizes would also allow investigation of a priori learner group classification based on measures of cognition.

Future research should also investigate the durability of learning in this population. For example, it would be expected that an identified "learner" would be a high performer on subsequent performance of the same task. Fiszdon et al. (2005) found that latency between training and retest indicated a decay of learning performance over time, however other research has found that training effects endure over time (Bell et al., 2003; Fiszdon et al., 2004). Future research in this area needs to be expanded to include follow-up testing for long term retention of the “learned” information. Exploration of the effects of cognitive remediation on long term memory would also have the potential to enhance recovery in people with serious mental illness.

Last, due to the important implications of this study with long term recovery outcomes, generalizability with other populations should also be explored in this area. Although cognitive deficits are prevalent in people with serious mental illness, they are also characteristic of a myriad of other medical and mental health populations. As such, the results of this study may have greater implications on the effect of cognitive interventions on long term neurological functioning. Currently, learning potential measurement efforts are limited in the ability to capture the full variability of performance within learner groups due to truncated distributions pre- and post-training (ceiling and floor effects). Some studies are beginning to explore alternative methods of capturing learning potential (Rempfer, McDowd, & Brown, 2012), however more studies are needed with different measures and in different clinical subgroups before these results could be generalized outside of the current study population.

Summary

Overall these results suggest that, compared with other neurocognitive variables, working memory may have the strongest influence on learning potential performance among people with serious mental illness. Further, attention does not appear to directly influence learning potential above other areas of cognition. Tasks of working memory demonstrated differential (stronger) relationships with dynamic performance (learning potential) compared with static performance. Finally, despite the strong influence of working memory skills on learning potential performance, the relative contribution of these skills, even combined with other areas of cognition and clinical and demographic factors, were not strong enough to reliably predict learner status. Again it is likely that a combination of factors (and/or a variable not included in this research, such as motivation), may serve as an effective predictor of learner status above what is included in this study.

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