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Role of learning potential in cognitive remediation: Construct and predictive validity

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ABSTRACT

Background: The construct, convergent, discriminant, and predictive validity of Learning Potential (LP) was evaluated in a trial of cognitive remediation for adults with schizophrenia-spectrum disorders. LP utilizes a dynamic assessment approach to prospectively estimate an individual's learning capacity if provided the opportunity for specific related learning.
Methods: LP was assessed in 75 participants at study entry, of whom 41 completed an eight-week cognitive remediation (CR) intervention, and 22 received treatment-as-usual (TAU). LP was assessed in a "test-train-test" verbal learning paradigm. Incremental predictive validity was assessed as the degree to which LP predicted memory skill acquisition above and beyond prediction by static verbal learning ability.
Results: Examination of construct validity confirmed that LP scores reflected use of trained semantic clustering strategy. LP scores correlated with executive functioning and education history, but not other demographics or symptom severity. Following the eight-week active phase, TAU evidenced little substantial change in skill acquisition outcomes, which related to static baseline verbal learning ability but not LP. For the CR group, LP significantly predicted skill acquisition in domains of verbal and visuospatial memory, but not auditory working memory. Furthermore, LP predicted skill acquisition incrementally beyond relevant background characteristics, symptoms, and neurocognitive abilities.
Conclusions: Results suggest that LP assessment can significantly improve prediction of specific skill acquisition with cognitive training, particularly for the domain assessed, and thereby may prove useful in individualization of treatment.

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1. Introduction

The term "learning potential" was initially applied to the assessment of training potential and educability of individuals with low IQs (Budoff and Friedman, 1964). Learning potential (LP) is quantified using a *dynamic assessment* approach intended to represent one's ability to quickly learn and apply a new skill under testing conditions, typically utilizing a "test-train-test" format. Dynamic assessment captures change in performance over time that occurs as a result of brief training, and in this way differs from static assessment, which is based on test performance at a single occasion without specific training. While static assessment captures current ability, it may not capture cognitive *capacity*. As such, dynamic LP assessment may inform prediction of future potential given adequate opportunity for learning or, in clinical context, intervention (Grigorenko, 2009).

Some forms of LP assessment share similarities with compensatory skills training used in cognitive remediation (CR), where capacity to perform a given task can be enhanced by training and practice in the use of strategies that reduce cognitive load. These and other approaches of CR have been found generally efficacious for individuals with schizophrenia-spectrum disorders (SSD) (McGurk et al., 2007; Wykes et al., 2011), but substantial variability in treatment outcome within and between studies raises questions about what individual differences influence response to treatment (Radhakrishnan et al., 2015). In particular, little is known about how background characteristics related to learning capacity influence treatment outcome (Green et al., 2000; Green et al., 2015; Kurtz, 2012). Given the time- and labor-intensive nature of CR, there is value in identifying variables that predict treatment efficacy and that could be used to inform and personally tailor treatment.

LP measures have been found to relate to readiness to learn in individuals with SSD (e.g., Fiszdon et al., 2006; Rempfer et al., 2011). LP has predicted treatment outcome incrementally above prediction by static factors in vocational rehabilitation (Sergi et al., 2005; Watzke et al., 2008; Watzke et al., 2009) and CR (Boosman et al., 2014; Wiedl and Wienobst, 1999). Previous research indicates that LP may not relate

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strongly to skills developed in the absence of related interventions (e.g., Green et al., 2015; Kurtz et al., 2010; Tenhula et al., 2007; Vaskinn et al., 2008). We suggest the utility of LP as a predictor of outcome will depend both on the capacity being assessed and the opportunity to develop that capacity through specific training.

Given that the "train" portion of the "test-train-test" in LP assessment often directly mirrors essential components of learning that contribute to efficacy of CR, effective measures of LP may have unique predictive power, beyond other background characteristics, as predictors of CR outcomes. The utility of LP assessment has been questioned in some cases due to limited relationship to functional status (Green et al., 2015), however, different methods of quantifying LP assessments have been shown to greatly influence their strength of association with other measures (Fiszdon and Johannesen, 2010). Thus, in determining the predictive utility of LP measures, one should also consider basic psychometric aspects of the derived LP score as well as construct validity with respect to outcome domain.

The current study examined the utility of LP assessment as a predictor of individual differences in skill acquisition during CR training among individuals with SSD, as well as LP's construct (convergent and discriminant) validity and incremental predictive validity. LP was assessed using a test-train-test administration of the California Verbal Learning Test-II (CVLT-II; e.g., Fiszdon et al., 2006) prior to an eight-week course of CR. The present report focuses specifically on LP psychometrics and CR skill acquisition.

Four principal hypotheses were tested: (H1) As evidence of convergent construct validity, LP score will reflect use of trained strategy (semantic clustering); (H2) As evidence of discriminant construct validity, LP score will not be highly correlated with baseline measures of neurocognition or background illness characteristics; (H3) As evidence of predictive validity, LP will predict skill acquisition achieved through CR training, and (H4) As evidence of incremental predictive validity, the relationship between LP and skill acquisition will remain after controlling for baseline neurocognitive and background characteristics, as identified in H2.

2. Methods

2.1. Participants

Data presented here are part of a study of cognitive remediation (CR) efficacy and predictors of outcome in SSD. Data from a subsample (N = 43) was previously used in a comparison of LP computation methods (Fiszdon and Johannesen, 2010).

Volunteers with schizophrenia-spectrum diagnoses were recruited from outpatient clinics of VA medical center and local community clinics. Inclusion criteria were as follows: age 18–65, psychiatrically stable (no hospitalizations, changes in medications, or changes in housing in past 30 days), no substance abuse in past 30 days, and no evidence of serious traumatic brain injury or neurological disorder. Following baseline assessment, participants were randomly assigned (2:1 ratio) to CR (n = 50) or to treatment as usual (TAU; n = 25). The study was approved by local Institutional Review Boards and all participants provided written informed consent prior to initiating any study procedures.

2.2. Intervention

The CR intervention consisted of up to five hours of weekly training over 8 weeks. Individuals were randomized to complete 4 weeks of computerized training, focused on memory and attention (PSS CogReHab; Bell et al., 2001) prior to or following 4 weeks of individualized compensatory cognitive training (CRT; Delahunty et al., 2001). Individuals randomized to TAU continued to receive their usual psychiatric and psychological services.

2.3. Measures

A comprehensive assessment battery was administered at intake and at the end of 8 weeks. Variables collected included background characteristics that have been found to predict skill acquisition in CR, including age, gender, education, IQ, symptom severity, reasoning and problem solving, and attention (Fiszdon et al., 2005; Kurtz, 2012; Medalia and Richardson, 2005; Scheu et al., 2013; Twamley et al., 2011).

2.3.1. Independent variables

Learning Potential (LP) was assessed using methods described in Fiszdon et al. (2006). Briefly, participants completed three administrations of the California Verbal Learning Test-II (CVLT-II), using three different stimulus sets of 16 words each, referred to hereafter as List 1 (pre-LP-train), List 2 (LP-train), and List 3 (post-LP-train). List 1 and 3 were administered using standard CVLT-II procedures, with List 2 administered as a "train" condition, involving instruction on semantic clustering strategies. Specifically, participants were shown how semantic grouping can improve recall, asked to practice using semantic grouping during all five trials of List 2, and given corrective feedback as needed.

LP was indexed by the extent of change in test performance from List 1 (pre-LP-train) to List 3 (post-LP-train) based on the regression residual scoring approach (Fiszdon and Johannesen, 2010), computed by regressing List 3 score (Trial 1–5 total) on List 1 score (Trial 1–5 total) and expressed as a standard score (z-score). Using this approach, individual scores represent the difference in List 3 (post-LP-train) performance relative to expected performance based on List 1 (pre-LP-train), with positive values indicating greater than expected improvement. The residual score provides an index of LP that effectively controls for differences in List 1 (i.e., pre-LP-train) performance and has distinct psychometric advantages compared to simple difference scores (Fiszdon and Johannesen, 2010; Guthke, 1982; Weingartz et al., 2008).

2.3.2. Clinical measures

Verbal learning was assessed using the California Verbal Learning Test – II (CVLT-II). Trial 1–5 total and semantic clustering scores, respectively, were used in analysis of incremental and construct validity. *Reasoning and problem-solving* was assessed using the Wisconsin Card-Sorting Task (WCST; Heaton, 1981) - standardized scores for percent errors and percent perseverative errors. *Attention and information-processing* was assessed using the Continuous Performance Task (CPT X/A; Loong, 1991). *Premorbid IQ* was estimated using the Wide Range Achievement Test 3 - Reading Subscale (WRAT-R; Johnstone et al., 1996; Wilkinson, 1993), and *current IQ* was assessed using the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999), two-subtest version. Illness severity was assessed using four variables: (1) age of onset; (2) age first hospitalized; (3) lifetime number of hospitalizations; and (4) Positive and Negative Syndrome Scale (PANSS; Kay et al., 1987; Bell et al., 1994) symptom rating.

2.3.3. Skill change outcome measures

Skill acquisition over the 8 week active phase was assessed based on pre-post performance scores on computerized cognitive tasks (CogReHab Software; Bracy, 1995) used in the CR intervention. Training administered in the active intervention involved a number of cognitive domains from which 3 memory tasks, differing in proximity to the domain of LP assessment (i.e., verbal learning), were selected. *Digits Auditory* is a progressive digits forward recall task assessing attention and working memory, which starts with 3 digits, and the number of digits presented increasing by one after each successful trial. Digits Auditory score is the total number of correctly recalled digits throughout the task. *Shape Place* is a spatial memory task in which multiple shapes are briefly displayed on a grid and once they disappear, participants are asked to select the shapes they saw and place them in their correct location on the grid. Shape Place score is the total number of shapes