PREDICTORS OF COMMUNITY OUTCOME IN SCHIZOHRENIA: THE FACTOR STRUCTURE OF COGNITION AND FUNCTIONAL CAPACITY

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Abstract

Cognition is considered a key predictor of community outcome in schizophrenia and is the target of an increasingly large number of pharmacological and behavioural interventions. The proliferation of functional capacity instruments grew out of the need to introduce a co-primary measure in intervention studies that was associated with cognition, related to community outcome, and face valid (Buchanan et al., 2005). While use of functional capacity measures has increased substantially, there is much variability in how this construct is understood and utilized. Theoretically, this ability is distinct from cognition; however, this distinction has not been established empirically. The current research examined the widely-held notion that functional capacity and cognition represent distinct constructs. This was achieved by performing an exploratory factor analysis on cognitive and functional capacity measures in an archival dataset (n = 96) followed by a confirmatory factor analysis on data collected at a second time-point (n = 95). Unlike previous studies, cognitive tests included in the analysis represented all cognitive domains claimed to be separable (Nuechterlein et al., 2004) and applied best practices for exploratory factor analysis (Costello & Osborne, 2005). The results indicated that cognition and functional capacity are determined by the same latent construct and should not be considered distinct. These results were then replicated with a second archival dataset (n = 155 and n = 128) which utilized different measures of cognition and functional capacity. Given that functional capacity instruments are redundant with cognitive measures, efforts will need to be invested into investigating alternative co-primary measures. Reaching a consensus on a co-primary measure will support the development of treatments aimed at improving community outcome.

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Table of Contents

List of Tables

List of Figures

Predictors of Community Outcome in Schizophrenia: The Factor Structure of Cognition and Functional Capacity

Schizophrenia is among the top most globally burdensome illnesses (World Health Organization, 2008) with only one in seven individuals demonstrating recovery in clinical and social functioning domains (Jääskeläinen et al., 2013). Indeed, reducing disability in this population remains a research and clinical challenge. This mental disease interferes with patients' ability to achieve educational milestones (Kessler, Foster, Saunders, & Stang, 1995) and subsequently maintain employment (Mueser, Salyers, & Mueser, 2001; Tsang, Leung, Chung, Bell, & Cheung, 2010). Accordingly, many individuals with schizophrenia live in poverty (Draine et al., 2002). Patients are also unlikely to live independently and have difficulty obtaining and even maintaining supported housing (Jaeger et al., 2015). Deficiency in understanding social behaviour is another characteristic of schizophrenia and contributes to impairments in community functioning, quality of life, and the social skills necessary for interaction with peers and clinicians (Couture, Penn, & Roberts, 2006). Together, functional impairments in community activities including academic, social, occupational, and independent living domains contribute to the high burden and disability associated with schizophrenia.

Extensive resources have been invested into research and clinical initiatives aimed at improving community outcome and thereby reducing functional disability in schizophrenia. Despite major advancements in treatments, the proportion of recovered cases has not increased in recent decades (Jääskeläinen et al., 2013). To address continued poor functionality in schizophrenia, research has focused on identifying determinants of community outcome. Attempts to understand this phenomenon have identified cognition as the best predictor of outcome (Green, Kern, & Heaton, 2004a). However, the US Food and Drug Administration

(FDA) noted that cognitive measures were limited in their predictive and face validity, leading them to require a more functionally meaningful co-primary (i.e., additional) measure of treatment effect on community outcome (Buchanan et al., 2005). In other words, for treatments to receive FDA approval, improvement must be demonstrated on cognitive measures as well as a measure that reflects abilities more obviously related to daily living than cognition. This requirement led to the proliferation of a new construct called *functional capacity*. Functional capacity refers to one's repertoire of daily living skills, as demonstrated by performance in ideal environments (i.e., free from environmental and social barriers). Although use of functional capacity measures has proliferated in recent years, evidence regarding whether they serve their intended purpose is conflicting. Some research has indicated that capacity measures add predictive validity over and above cognitive measures and mediate the relationship between cognition and community outcome (e.g., Bowie, Reichenberg, Patterson, Heaton, & Harvey, 2006; McDermid Vaz et al., 2013) while other evidence suggests that the two constructs overlap substantially and that functional capacity measures do not demonstrate incremental validity (e.g., Heinrichs, Ammari, Miles, & McDermid Vaz, 2010; Muharib et al., 2014). This conflicting state of community outcome research has prompted the need for a critical reappraisal of the relationship between cognition and functional capacity and the value of including both cognitive and capacity measures in predicting community outcome.

The Importance of Cognition in Schizophrenia

Cognitive impairment is widely regarded as a core deficit in schizophrenia. These deficits are detectable in high-risk groups prior to the onset of psychosis (Seidman et al., 2006; 2010), at first-episode (Mesholam-Gately, Giuliano, Goff, Faraone, & Seidman, 2009), and throughout the lifespan (Herold, Schmid, Lässer, Seidl, & Schröder, 2017). Patients perform at least one standard deviation, and sometimes up to 2.5 standard deviations, below controls across numerous neuropsychological tests (Heinrichs & Zakzanis, 1998; Keefe et al., 2011; Schaefer, Giangrande, Weinberger, & Dickinson, 2013). Specifically, seven cognitive domains have been demonstrated as consistently impaired in this population: verbal comprehension, processing speed, attention, working memory, verbal memory, visual memory, and reasoning (Nuechterlein et al., 2004).

While cognitive disturbances have been highlighted in this population since the establishment of schizophrenia as a mental illness (Kraepelin, 1919), the relative importance attributed to cognition today is largely due to its potential for mediating important aspects of community adjustment (Bowie & Harvey, 2006; Green et al., 2004a; Keefe & Harvey, 2012). Not only is cognition regarded as the strongest predictor of community outcome, but cognitive domains also differentially predict aspects of community independence (see Keefe & Harvey, 2012, for a review). For example, engagement in community activities and residential status is predicted by verbal memory abilities, social functioning is predicted by sustained attention, and daily living skills, vocational productivity, and social competence are predicted by executive functioning (Velligan, Bow-Thomas, Mahurin, Miller, & Halgunseth, 2000). Provided that key cognitive domains are amenable to change, interventions targeting cognition have the potential to influence community outcome and reduce the disability associated with schizophrenia.

The effects of research suggesting that improvements in cognition will reduce disability is reflected in the recent proliferation of cognitive remediation programs (Kurzban, Brekke, & Davis, 2010) and pharmacological initiatives (Brady, Winsky, Goodman, Oliveri, & Stover, 2009). Indeed, there now exists a large variety of cognitive remediation programs (McGurk & Mueser, 2013) and sizeable resources have been invested into their development, implementation, and evaluation. Likewise, large investments have been made by the pharmacological industry into the development of treatments that address cognitive impairments in schizophrenia. These behavioural and pharmacological initiatives are designed with the premise that improving cognition results in improved community outcome. However, the research demonstrating the effectiveness of these initiatives is limited. Instead, research has demonstrated that while cognitive skills training programs may improve cognition, these gains do not necessarily translate into improvements in community outcome (Dickinson et al., 2010; Green & Harvey, 2014). Instead, large-scale meta-analyses have suggested that it is the addition of psychiatric rehabilitation services (e.g., social or vocational skills training), and not the cognitive interventions per se, that bolster community outcomes (McGurk, Twamley, Sitzer, McHugo, & Mueser, 2007; Wykes, Huddy, Cellard, McGurk, & Czobor, 2011). Moreover, patients that show the greatest benefits from such interventions are those with better baseline cognitive performance (Farreny et al., 2016; Kurtz, 2011; Vita et al., 2013), meaning that the most cognitively disadvantaged patients, and presumably those with the most disability, remain impaired in their community functioning. Even when treatment gains associated with such interventions are made, the effect sizes are small to moderate across even the most methodologically rigorous cognitive remediation programs (Wykes et al., 2011) and there is little research to support the long-term maintenance of these gains (McGurk et al., 2007). Additionally, research suggests that advantages in cognitive abilities are associated with better functional capacity (i.e., skills) but not functioning in the community (Muharib et al., 2014). These results warrant the critical reappraisal of cognition as a driver of outcomes and have triggered the current investigation into the role of cognition in schizophrenia.

Indeed, several key challenges exist in the literature. First, although the consensus view maintains that cognition predicts community outcome, cognition alone accounts for a small fraction of variance, with a recent meta-analysis demonstrating that only as much as 16% of variance in outcome is explained by cognition (Fett et al., 2011). Nevertheless, other studies have reported larger effect sizes, noting that 20 to 60% of variance in outcome can be explained by cognition (Green, Kern, Braff, & Mintz, 2000). To advance the field, the relationship between cognition and community outcome needs to be re-examined. Additionally, research in the field has yet to identify which variables account for the unexplained variance and *how* cognition and other key variables relate to community outcome. Understanding these relationships will ultimately allow for the design and implementation of treatments that target mediators of outcome and thereby reduce disability. Accordingly, the current study investigated these relationships.

The Relationship between Cognition and Functional Capacity

Functional capacity, or the repertoire of daily living skills an individual possesses and is able to demonstrate, is a construct that has been developed to link cognition and community outcome. Functional capacity differs from community outcome in that it purportedly reflects what a person is capable of doing in an ideal environment as opposed to how they actually perform in the “real” world. This construct developed following concerns about the ecological validity of other assessment methods of functioning in patients with severe mental illnesses (Harvey, Velligan, & Bellack, 2007; Patterson, Goldman, McKibbin, Hughs, & Jeste, 2001). Specifically, self-reports are subject to bias, particularly in individuals with severe mental illnesses who typically have limited insight, and informant reports are not available for many people with schizophrenia as they either lack key informants or have limited contact with them (Brown & Velligan, 2016; Harvey et al., 2007). Additionally, direct observation of functioning would be impractical as a high time investment would be required to observe behaviours that occur infrequently in this population such as, for example, handling a power outage in one's home. In an attempt to create more objective, reliable, and functionally valid indices of community outcome, the University of California San Diego (UCSD) Performance-Based Skills Assessment Battery (UPSA; Patterson et al., 2001) and similar performance-based measures of functional capacity such as the Canadian Objective Assessment of Life Skills (COALS; McDermid Vaz et al., 2013) were developed. Such measures have trained researchers and clinicians observe patients roleplay real-life tasks such as transportation scheduling or meal planning in a laboratory environment.

Following pressure from the US FDA to include a clinically meaningful and face valid co-primary outcome measure of functional improvement in intervention studies (Buchanan et al., 2005), use of functional capacity measures has proliferated. While these instruments are meant to act as proxy measures of functioning in the community (i.e., what an individual *could* do in the community; Buchanan et al., 2005), there is much variability in how this construct is understood and utilized. For example, some researchers have erroneously used capacity measures interchangeably with or instead of measures of community outcome (e.g., Fett et al., 2011), others have reported that functional capacity mediates the relationship between cognition and outcomes (e.g., Bowie et al., 2006), and others yet have suggested that they may be redundant with measures of cognitive abilities (e.g., Harvey et al., 2013, 2016; Heinrichs et al., 2010).

In light of its popularity and theorized utility, the nature of this construct and its relation to cognition requires further clarification. More specifically, use of this construct has increased as a result of its presumed ability to better predict changes that may lead to improvements in community outcome. Additionally, many study designs and associated interpretations of research findings are contingent upon the idea that cognition and functional capacity represent distinct, but related, constructs. For example, Bowie and colleagues (2006) collected functional capacity, cognitive, symptom, and community outcome data on schizophrenia patients and used confirmatory path analyses to examine how neuropsychological performance is related to community outcome. The researchers concluded that functional capacity mediates the relationship between cognition and most aspects of community functioning (e.g., interpersonal skills, community activities, and work skills) but cautioned that functional capacity measures require cognitive skills and thus reported that measurement error was introduced in predicting capacity performance. This limitation is particularly relevant as the conclusions of this and other studies were based on the implicit assumption that functional capacity and cognition represent distinct constructs. However, the validity of this assumption is largely untested and hence the conclusions of such studies may be inaccurate.

Given that cognition and functional capacity are both considered key correlates of outcomes, elucidating the nature of these constructs will allow for a better understanding of the complex phenomenon of community outcome. Nuechterlein and colleagues (2004) suggest that the highest level of support for independence of abilities is evidence of distinct neural underpinnings that respond differently to pharmacological interventions. Alternatively, independence of abilities may be established statistically through factor analytic studies and weak correlations (e.g., $r < .4$; Nuechterlein et al., 2004); the present study attempts to address the nature of these abilities through these statistical methods. Of note, existing research has not demonstrated that cognition and functional capacity are separate abilities but, instead, suggests that performances on tasks measuring these abilities are strongly correlated and may even be determined by the same underlying processes (e.g., Harvey et al., 2013, 2016).

Multiple lines of research have indicated that the constructs of cognition and functional capacity are highly overlapping. Indeed, strong positive correlations have been consistently demonstrated between tests of functional capacity and a broad range of neuropsychological measures (e.g., Bowie et al., 2006; Keefe, Poe, Walker, & Harvey, 2006; Twamley et al., 2002). Despite the use of different cognitive measures, the correlation between performance on a range of traditional neuropsychological tasks and the UPSA is typically in the $r = .60$ to $r = .65$ range (Leifker, Patterson, Heaton, & Harvey, 2011) and sometimes reaches as high as .79 (Pietrzak et al., 2009). To put this figure into perspective, a meta-analysis of between-domain correlations across neuropsychological tasks used in the schizophrenia literature found that the average correlation between cognitive measures was $r = .37$, with a range of $r = .24$ to $r = .49$ (Dickinson & Gold, 2008). Similar correlations can be found among other cognitive tests, such as those contained within the Wechsler Adult Intelligence Scale-Fourth Edition (WAIS-IV; Wechsler, 2008), whereby correlations between WAIS-IV tests are typically in the $r = .4$ to $r = .5$ range. Thus, not only are correlations between cognition and functional capacity substantial, but they are higher than typical correlations across neuropsychological measures and cognitive domains.

Other types of correlational analyses have also addressed the relationship between cognitive and functional capacity variables. McClure and colleagues (2007) examined associations between different neuropsychological abilities and performance-based measures of social and living skills. Two canonical roots were differentially associated with these aspects of functional capacity; processing speed, episodic memory, and executive functions were associated with everyday living skills (as measured by the UPSA) while working memory, episodic memory, and verbal fluency were associated with social competence (measured by another performance-based measure of functional capacity).

To date, only two factor analytic studies have been conducted on cognitive and functional capacity measures in schizophrenia. The first was a study that examined the longitudinal factor structure of these measures and indicated that the two may be determined by a single construct (Harvey et al., 2013). Moreover, the group demonstrated that an advantage of neuropsychological tests was their higher test-retest reliabilities relative to functional capacity measures. The second study looked at the factor structure of traditional neuropsychological and functional capacity measures in two studies of patients with schizophrenia and bipolar I disorder (Harvey et al., 2016). This study concluded that performance on these measures is best explained as a single latent trait in both patient groups. Although the results of these studies are consistent, they have notable limitations. First, neither study assessed the full range of cognitive domains relevant to community outcome in schizophrenia (as outlined by Nuechterlein et al., 2004). Second, the samples in the Harvey and colleagues (2016) study differ from typical patients with schizophrenia in that they consisted of either veterans who were older and had a later onset of schizophrenia or individuals with Ashkenazi Jewish background who are typically more educated than individuals with schizophrenia and the US population as a whole. Thus, the results may not generalize to the overall schizophrenia population. Lastly, although choice of statistical analyses (e.g., rotation methods) are known to influence the results of factor analysis, these authors did not explain several important details of how their analyses were conducted and the analyses that were explained are not consistent with best practices (i.e., Costello & Osbourne, 2005). Nonetheless, this preliminary research suggests that the tendency to consider cognition and functional capacity as distinct constructs may be inaccurate.

If these abilities do represent the same construct, then an important consideration is whether capacity measures provide incremental validity over and above cognition measures.

However, the literature presents conflicting data on this matter as some studies have reported added predictive validity by capacity measures beyond that accounted for by cognitive measures (e.g., McDermid Vaz et al., 2013), while others have demonstrated that capacity measures contribute very little to no incremental validity (Heinrichs et al., 2010; Heinrichs, Statucka, Goldberg, & McDermid Vaz, 2006; Twamley et al., 2002). For example, in a study examining the benefit of intact cognitive abilities in schizophrenia, functional capacity measures did not provide any predictive validity over and above cognitive functioning (Muharib et al., 2014). Moreover, while a group of patients with schizophrenia in this study demonstrated cognitive and functional competence equivalent to cognitively average controls and better than that of patients with impaired cognition, their community outcome was worse than that of controls and equivalent to patients with impaired cognition. It is unclear whether the variability in functional capacity measures' ability to predict community outcome over and above cognitive measures reflects differences in the clinical and demographic characteristics of the study samples, differences in the instruments used to measure capacity (e.g., item content or difficulty level), or if it is a feature of the functional capacity construct itself.

While functional capacity measures were introduced to provide a more ecologically valid proxy of everyday functioning, whether they resolve the problem of capturing more variability in community functioning remains controversial. Although some research has focused on clarifying the mechanisms by which constructs such as cognition and functional capacity predict outcomes, the validity of the constructs in question is seldom evaluated beforehand. Instead, these variables are entered into analyses such as confirmatory factor analyses (CFA) as distinct constructs without exploration of their own factor structure first (e.g., Bowie et al., 2006, 2008; Strassnig et al., 2015). While exploratory factor analysis (EFA) is not a mandatory pre-requisite to CFA, it is highly recommended when the distinctness of the constructs has not been validated; otherwise, analyses can lead to inaccurate results.

Considering the degree of shared variance between cognition and functional capacity (e.g., Keefe et al., 2006), examining whether these constructs are distinguishable will allow for increased confidence in the interpretation of research findings that draw conclusions about community outcome. For example, several lines of research suggest that functional capacity mediates the relationship between cognition and community outcome. This finding has treatment implications as more proximal measures of community outcome are expected to more directly affect functioning in the community and are therefore considered more viable treatment targets. Lastly, elucidating the nature of the relationship between functional capacity and cognition will provide insight into whether functional capacity measures serve their intended purpose (i.e., serve as a distinct but related co-primary measure) and if their use continues to be appropriate in predicting community functioning alongside cognition.

If these abilities are distinguishable and therefore the conclusions of previous studies demonstrating that functional capacity mediates the relationship between cognition and community outcome are accurate, then treatments targeting functional capacity have the potential to be more successful in improving community outcome than those aimed at improving cognition. If these variables are not distinct, then use of both in outcome studies would not only be inefficient, but would also not meet the FDA requirement for the inclusion of a separate co-primary measure in intervention trials. Accordingly, a determination would need to be made regarding which type of measure is more appropriate, and in which contexts. Clarifying the relationship between these constructs will also assist researchers in determining whether new co-primary measures need to be considered which may subsequently contribute to improving community outcome.

The Structure of Cognition

Within the framework of key predictors of community outcome, the factor structure of cognition also remains uncertain. This uncertainty becomes particularly relevant when evaluating the nature of the relationship between cognition and community functioning as well as when evaluating the relation between capacity and cognition. In the absence of treatments reducing disability in schizophrenia, the development of pharmacological treatments with the potential to impact cognition have become a high priority (Buchanan et al., 2005) and substantial efforts have been invested into this initiative. Certain pharmacological agents are expected to have circumscribed effects on aspects of cognition (Nuechterlein et al., 2004; Reilly & Sweeney, 2014), and thus capturing discrete effects is of paramount importance in assessing the effectiveness of pharmacological agents and gaining FDA approval. The clinical relevance of identifying separable cognitive abilities in schizophrenia highlights the rationale behind the development of the Measurement and Treatment Research to Improve Cognition in Schizophrenia (MATRICS), Consensus Cognitive Battery (MCCB; Nuechterlein et al., 2008), a battery intended to capture cognitive domains that may be impacted by pharmacological treatments. This battery was assembled after inspection of the literature by an expert panel identified seven consistently impaired cognitive domains in schizophrenia including verbal comprehension, processing speed, attention, working memory, verbal and visual memory, and reasoning (Nuechterlein et al., 2004); six of these domains were considered appropriate targets for pharmacological interventions aimed at improving cognition. The panel also indicated that these domains reflect separate abilities; a claim that has important treatment implications.

One of the largest studies to explore the claim of separable cognitive abilities was by Keefe and colleagues (2006) who used data from the Clinical Antipsychotic Trials of Intervention Effectiveness (CATIE) schizophrenia trial. This sample consisted of a heterogeneous cohort of 1,493 schizophrenia patients from 48 cities across the United States. With the exception of verbal comprehension and visual memory, their selected tests represented the same cognitive domains identified by the expert panel. The results of their EFA suggested that a one-factor model consisting of five domain scores, as opposed to nine test summary scores, best explained the data. Nevertheless, this single factor only accounted for 45% of the variance in the data. In contrast to a one-factor solution, an extensive body of literature has argued that cognition in schizophrenia is best explained by multi-factor models. However, the number of factors identified has varied from as few as two factors (Mohn, Lystad, Ueland, Falkum, & Rund, 2017) to as many as six (Gladsjo et al., 2004; Ojeda, Pena, Sanchez, Elizagarate, & Ezcurra, 2008), and while studies have used different batteries, even those employing similar measures or representing the same cognitive domains have yielded different results. For example, a study by Bowie and colleagues (2008) used measures that represented the same cognitive domains as Keefe et al. (2006) but determined that a four-factor model best explained the data. The four factors included attention/working memory, verbal memory, processing speed, and executive functions. Yet another study examined the factor structure of cognitive domains in schizophrenia patients (Burton et al., 2013) but did so using the MCCB. As noted, this measure was developed based on the recommendations of the aforementioned expert panel. These authors determined that a three-factor model representing processing speed, working memory/attention, and memory domains best fit the data. In addition to the lack of replicability of results, a key limitation across these studies is that none included measures of verbal comprehension and both the Keefe et al. (2006) and Bowie et al. (2008) studies failed to include measures of visual memory. Nonetheless, both of these cognitive domains are considered important in this population as they have been found to be consistently impaired in, and functionally relevant to, schizophrenia (Heinrichs & Zakzanis, 1999; Nuechterlein et al., 2004). Thus, none of the analyses investigating the factor structure of cognition have considered the full range of relevant neuropsychological domains.

Another key limitation of studies examining the factor structure of cognition involves the statistical methods used to define latent constructs, in particular the extraction and rotation methods. Best practices recommend EFA (e.g., rather than principal components analysis, or PCA) for exploration of factor structure and suggest the use of oblique rotations to allow correlated latent variables (Costello & Osborne, 2005); however, researchers do not typically adhere to these recommendations. In attempting to determine the key separable cognitive impairments in schizophrenia, Nuechterlein et al. (2004) reviewed the empirical evidence for cognitive domains in schizophrenia, with a particular focus on factor analytic studies. Of the 13 studies identified by their review, nine had used principal component analysis (PCA) as their extraction method. Additionally, Varimax rotation, an orthogonal rotation method, was most commonly employed. These statistical methods continued to be applied to the more recent factor analytic studies described above which either only used CFA, used PCA, or assessed factor structure with EFA but with an orthogonal rotation method. Given that cognitive factors are typically moderately correlated (e.g., Keefe et al., 2006; Dickinson & Gold, 2008), use of orthogonal rotations is inappropriate. Additionally, although PCA is the most common extraction method in the social sciences, it is a data reduction method that does not take into account the underlying structure caused by latent variables (Costello & Osborne, 2005). In contrast, in an

EFA, the shared variance of a variable is separated from unique variance and error variance to establish the underlying factor structure. A limitation of PCA, which does not apply to EFA, is that this factor analytic method uses all variances to determine components and can yield exaggerated values of variance accounted for by the components.

These varied and less optimal statistical methods for exploring the factor structure of cognition in schizophrenia present another explanation for disparate results and why the factor structure of cognition remains unknown; this situation subsequently presents a challenge for unpacking predictors of outcomes. Taking this background into account, one of the goals of the present study included better understanding the factor structure of cognition by including all seven cognitive domains identified by the expert panel and applying best practices for factor analysis.

Community Outcome in Schizophrenia

Community outcome in schizophrenia is a complex and a multi-determined construct. Essentially, it refers to how an individual functions in their community. Alternate terms of this construct include functional outcome, functional disability, functional status, everyday functioning, real-world outcome, community functioning, and community independence. Researchers have employed these terms with slightly varying operational definitions. In defining community outcome, the present study took into account three elements: whether an individual is performing roles in various settings (i.e., educational, residential, or occupational), how well they perform the role, and what supports they receive to perform the role (Jaeger, Berns, & Czobor, 2003). To illustrate these elements, consider two individuals who are attending university. On the surface, it may seem that this educational milestone is indicative of “good” community functioning. However, further inspection reveals that one student is in their first year, is taking a partial course load, attends classes only after receiving prompts from family members, and barely passes their courses, while the other is completing their final semester, is self-motivated, taking a full course load, and achieves a ‘B’ average; these two individuals are displaying varying levels of community outcome. Accordingly, our definition of community outcome not only takes into account role position (e.g., in university vs. not in university or first year vs. fourth year), but also performance (e.g., ‘D’ average vs. ‘B’ average), and supports for role completion.

Numerous variables have been proposed as predictors of community outcome. Of these, cognition, functional capacity, psychopathology, and social cognition have received the most research backing. Given that the roles of cognition and functional capacity in community functioning have already been explored in this paper, the next sections will review the contributions of psychopathology and social cognition to functioning in the community.

Psychopathology. Psychopathology in schizophrenia has traditionally been divided into two categories: positive symptoms and negative symptoms (Andreasen & Olsen, 1982). Positive symptoms refer to symptoms that are in excess of normal functions (e.g., hallucinations, delusions, etc.) while negative symptoms refer to an absence or reduction of regular functions (e.g., blunted affect, emotional withdrawal, etc.). Additionally, there is a host of other “general” or non-psychotic symptoms which individuals with schizophrenia may experience, such as anxiety, depression, or somatic concerns, among others. Research has shown that positive, negative, and general psychopathology can account for almost half of the outcome variance seen in patients with schizophrenia and that symptoms contribute to the prediction of outcomes independently of cognition (Heinrichs et al., 2009).

While the presence of positive symptoms are a prerequisite for a diagnosis of schizophrenia (American Psychiatric Association, 2013) and add unique variance to outcome performance (Heinrichs, Ammari, Miles, McDermid Vaz, & Chopov, 2009; Wittorf, Wiedemann, Buchkremer, & Klingberg, 2008), negative symptoms are considered more predictive of poor community functioning, partly due to findings that improvement in psychotic symptoms has limited functional impact (Hegarty, Baldessarini, Tohen, Waternaux, & Godehard, 1994; Jääskeläinen et al., 2012). Instead, negative symptoms, which are typically more persistent throughout the illness course (i.e., visible in chronically and acutely ill patients and during periods of positive symptoms remission), are believed to be more closely tied to functioning levels (Bozikas et al., 2006; Tamminga, Buchanan, & Gold, 1996).

The severity of negative symptoms is associated with functioning in the community and social behavior (Bozikas et al., 2006; Smith, Hull, Huppert, & Silverstein, 2002). Reduced motivation is a key negative symptom that has been identified as contributing to poor community outcome. In fact, some researchers have found amotivation to be the most robust predictor of community outcome (Fervaha, Foussias, Agid, Remington, 2013; Foussias et al., 2011), sometimes with little to no additional predictive validity offered by cognition (Konstantakopoulos et al., 2011). This result, however, is at odds with other research which has demonstrated an association between cognition and community outcome even after controlling for motivation levels (Fervaha, Foussias, Agid, & Remington, 2014; Green, 1996; Green et al., 2000) and with research showing that cognition and symptoms each independently contribute to the prediction of community outcome (Heinrichs et al., 2009). Others report that the severity of negative symptoms is related to cognition and community outcome and that negative symptoms mediate the relationship between cognition and outcomes (Ventura, Hellemann, Thames, Koellner, & Nuechterlein, 2009). These conflicting reports again highlight the current limited understanding of disability and further underscore the need to evaluate how these factors predict community outcome in concert. To further complicate matters, yet another variable has been claimed to be the most predictive of community outcome: social cognition.

Social Cognition. Social cognition has been defined as the mental processes that allow individuals to "understand, act on, and benefit" from interpersonal interactions (Corrigan & Penn, 2001). This construct has recently received a lot of attention in the schizophrenia literature as researchers have hypothesized that impairments in social cognition may explain difficulties with forming and maintaining interpersonal relationships and subsequently influence performance in functional domains such as education, employment, and residential living (Green & Horan, 2010; Green, Horan, & Lee, 2015, Mancuso, Horan, Kern, & Green, 2011).

Social cognition is differentiated from non-social cognition in that it includes social and emotional processing while non-social cognition does not. Research has indicated that social cognition represents a distinct ability from non-social cognition (Sergi et al., 2007). Social cognition has been conceptualized as being composed of four somewhat overlapping skill sets: emotional processing, social perception, attribution style, and theory of mind (Green & Horan, 2010; Green, Olivier, Crawley, Penn, & Silverstein, 2005). Emotional processing refers to the ability to perceive affective information from others. Social perception refers to the ability to understand social roles and conventions within a social context. Attribution style refers to the idiosyncratic inferences of causes of events (i.e., due to others, oneself, or the situation). Lastly, theory of mind includes the capacity to both recognize that others have their own mental states and the ability to correctly infer the intentions or beliefs of others. Individuals with schizophrenia demonstrate impairments in all of these domains (Green & Horan, 2010). Moreover, the magnitude of impairments in these skill sets is large (Salva et al., 2013). A meta-analysis revealed that relative to controls, schizophrenia patients performed worse across all domains, with standardized mean differences or Hedges' g = 1.04 for social perception, Hedges' g = 0.96 for theory of mind, Hedges' g = 0.89 for emotion perception, and Hedges' g = 0.88 for emotion processing (Salva, Vella, Armstrong, Penn, & Twamley, 2013); indicating large statistical differences between patients and controls across all social cognitive domains.

Difficulties with social cognition have been shown to add incremental validity to the prediction of community functioning beyond that accounted for by non-social cognition and symptoms (e.g., Mancuso et al., 2011) and mediate the relationship between cognition and community outcome. Sergi, Rassovsky, Nuechterlein, and Green (2006) demonstrated that social perception mediates the relationship between early visual processing and functional status. This study was a significant contribution to the field as the authors chose a very basic aspect of cognition (i.e., early visual processing) which temporally precedes social cognition. This choice of measure clarified that social cognition mediates the relationship between cognition and community outcome instead of the reverse pattern (i.e., cognition mediating the relationship between social cognition and outcome). This distinction is pertinent as it provides a treatment target because interventions aimed at reducing disability would need to target aspects of the model most closely related to community outcome. The results of this study are consistent with other studies that also demonstrated that social cognition mediates the association between cognition and community outcome (e.g., Addington, Girard, Christensen, & Addington, 2010; Gard, Fisher, Garrett, Genevsky, & Vinogradov, 2009; Vauth, Rusch, Wirtz, & Corrigan, 2004).

Gard and colleagues (2009) devised a study in which they attempted to integrate neuropsychological, psychological, and socio-behavioural variables into a model that would explain mediating pathways from social cognition and cognition to community outcome. Specifically, they collected cognitive, social cognitive, and negative symptom (motivation) data and examined how these variables relate to one another and to community outcome. The results of their study indicated that social cognition mediates the relationship between neurocognition and functional outcome and that motivation further plays a mediating role in the relationship between neurocognition, social cognition, and functional outcome. This study is a significant improvement on previous models because it includes aspects of cognition, social cognition, and negative symptoms in predicting outcomes. Moreover, it is consistent with current perspectives (i.e., Green et al., 2005) that inclusion of cognitive, social cognitive, and psychological variables in models may best advance understanding of the causal determinants of functional outcome in schizophrenia. However, this study did not include or consider the role that functional capacity may play in explaining outcomes. Current research must consider all relevant variables, determine whether previous results can be replicated, and assess which models of outcome account for the greatest amount of variance in community outcome.

Current Study

To review, improving community functioning in schizophrenia continues to be a clinical and research challenge. A significant body of literature suggests that cognition is the best predictor of community outcome. However, cognition only captures a small fraction of the variability in community outcome and improvements in cognition do not necessarily translate to improvements in daily functioning. Accordingly, the FDA recommended that a more clinically meaningful measure be introduced to capture everyday functioning. The resultant measures, which have been conceptualized as reflecting the construct of functional capacity, have gained popularity in the outcome literature and have empirical support as mediators of the relationship between cognition and community outcome. However, it is unclear whether these performance-based measures represent a construct that is truly distinct from cognition. Resolving this issue is important because the conclusions of previous analyses that have sought to predict community outcome depend on the assumption that these variables are distinct. Without empirical evidence of this, resulting conclusions may be incorrect and may be hampering efforts to better understand community outcome and reduce disability. Moreover, determination of the factor structure of cognitive domains relevant to functioning in schizophrenia also requires evaluation as the approval of pharmacological treatments for cognitive impairments are contingent on the understanding that these domains are separable and that discrete cognitive changes are capable of being differentially assessed by traditional neuropsychological measures. Accordingly, the first goal of the present research study is to determine whether cognitive and functional capacity abilities represent the same underlying construct. Results of the first part of this study will be used to inform the second part of the study which will assess the predictive validity of cognitive, social cognitive, symptom, and possibly functional capacity data with respect to community outcome.

Current research in schizophrenia is interested in the mechanisms by which cognition accounts for community outcome and the role that functional capacity plays in this relationship. An essential first step in unpacking the respective contributions of several predictors of outcomes includes understanding what these constructs truly represent. Although cognition and functional capacity are theoretically distinct, this assumption has not been validated empirically. The factor structure of these constructs has both clinical and methodological implications. Clinically, if neuropsychological and capacity instruments measure the same construct, then administration of both measures would be redundant and inefficient. Additionally, cognitively enhancing treatments in schizophrenia require evidence of change on both cognitive and a separate co-primary measure to demonstrate a treatment effect. If these constructs are not distinct, then the current use of functional capacity measures would be inappropriate and alternative co-primary measures would need to be identified and used instead (Harvey et al., 2013). Methodologically, determining whether these constructs are dissociable prior to estimating CFA models will allow for more complete interpretations of data. If these constructs are not distinguishable and functional capacity may just be a more face valid measure of cognition, as several lines of research have suggested, then analyses determining contributors to outcome will need to be reconsidered. For example, recent studies which attempted to uncover the relationship between capacity, cognition, symptoms, and outcome indicated that capacity mediates the relationship between cognition and community outcome (e.g. Bowie et al. 2006; 2008). However, if capacity and cognition represent the same construct, then the observed variables (i.e., performance on cognition and capacity measures) should comprise one latent variable. Including these observed variables as one factor is expected to produce different results than those previously reported. Progress cannot be made until there is a clearer understanding of how cognition and functionality are related.

Accordingly, the aim of the present investigation is to evaluate the validity of this dual model of cognition and functional capacity in schizophrenia. This will be achieved by performing an EFA of cognitive and functional capacity measures in an archival dataset. Unlike previous publications, cognitive tests included in this analysis will represent all cognitive domains claimed to be separable (Nuechterlein et al., 2004), including: verbal comprehension, reasoning, processing speed, attention, verbal memory, visual memory, and working memory. While previous factor analytic studies have consistently excluded verbal comprehension because it is considered resilient to change (both neurological and pharmacological), the present study will include this ability as it seeks to explore the full range of functionally-relevant cognitive domains. The results of the EFA will determine the optimal number of factors underlying these variables. The number of factors proposed by these analyses will then be evaluated for model fit through CFA and expanded to a larger structural equation model (SEM) to evaluate how well they predict community outcome. To ascertain that the results are not a function of the selected measures, the analysis will then be repeated on a second archival dataset with different measures of cognition and capacity. Thus, both new and less standard measures of functional capacity and cognition will be analyzed.

Hypotheses. It is hypothesized that a four-factor model will emerge, representing verbal ability, processing speed, memory, and a single factor influencing working memory and attention. Such results would be similar to those found by Burton and colleagues (2013) who examined the factor structure of domains contained within the MCCB, but would also include a verbal ability factor, a domain not measured in their study. It is further hypothesized that measures of functional capacity will not represent a distinct factor but will instead be determined by one or more cognitive factors. Statistical support for a model in which cognition and capacity load on the same factor(s) would suggest that these constructs represent the same underlying latent variable(s) and that their inclusion as distinct predictors in outcome studies has led to misleading conclusions. If the same construct underlies cognition and capacity, accepted models of community outcome will need to be revisited.

Elucidating the nature of these constructs is only the first step in clarifying which variables predict community outcome and how they combine to do so. Regardless of whether cognition and capacity are redundant, the problem of improving community outcome remains.

Accordingly, the second part of the current study will use results from the EFA to assess the ability of cognition and functional capacity (either as a single factor or two factors), symptoms, and social cognition to predict community outcome. Using structural equation modeling, the present study will examine the latent variable predictors of community outcome, their relationship to one another, and the total amount of variance in outcome that can be predicted by these constructs.

Method

Dataset One

Participants. Individuals with schizophrenia or schizoaffective disorder were recruited from three outpatient clinics in Hamilton, Ontario: the Cleghorn Early Intervention in Psychosis Program, the Hamilton Program for Schizophrenia, and the Community Schizophrenia Service. This sample was recruited through flyers posted at these settings and referrals by case workers. To participate in the study, patients had to meet several inclusion criteria including: 1) a confirmed diagnosis of schizophrenia or schizoaffective disorder by the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID-I; First, Spitzer, Gibbon, & Williams, 1996) with no concurrent diagnosis of substance use disorders; 2) no history of a developmental or learning disability; 3) no history of a neurological or endocrine disorder; and 4) age between 18 and 65 years. These criteria yielded 100 participants. The demographic and clinical characteristics of patients in dataset one are reported in Table 1.

Measures. Neuropsychological measures assessing cognitive domains relevant to the schizophrenia population (as identified by Nuechterlein et al., 2004) were administered to all participants. To assess these domains, the MCCB was administered. As mentioned, this battery assesses six cognitive ability factors including processing speed, working memory, verbal learning and memory, visual learning and memory, reasoning and problem solving, and attention/vigilance. All MCCB cognitive domains were included in the analysis. The social cognitive task in the MCCB was not included in the EFA (but was included as a covariate in the CFA) because it represents an empirically and neurobiologically distinct ability from non-social cognition (Green et al., 2008; Fett et al., 2011). Finally, the Vocabulary subtest of the Wechsler Abbreviated Scale of Intelligence (WASI; Psychological Corporation, 1999) was used as a measure of verbal comprehension.

The Multidimensional Scale of Independent Functioning (MSIF; Jaeger et al., 2003) is a measure of "real-world" or community outcome in mental health outpatients. It was designed to address the shortcomings of other community outcome instruments such as their limited ability to assess disability in major life roles as well as changes over time in adaptive behaviour, overall functioning, and activities of daily living. The MSIF assesses functioning in three domains across three environments: assessments are made of an individual's expected role responsibility (i.e., role position), support received for that role (i.e., support), and quality of productive activities (i.e., performance) across work, educational, and residential settings. Ratings for each dimension in each of these three settings are made along a 7-point Likert-type scale, with lower scores reflecting better functioning. Detailed anchors are provided to increase reliability by providing common reference points for interviewers (Jaeger et al., 2003).

As noted, the COALS (McDermid Vaz et al., 2013) is a performance-based measure of capacity to perform everyday functioning. This measure assesses five functional domains relevant to independence in the community: health and hygiene, time management, transportation, crisis management, and domestic activities. Participants are instructed to either roleplay or respond to situations considered important for independent living (e.g., which bus route to take to arrive at an appointment on time or how to prepare a nutritious meal for dinner). Participants are scored on each of the five domains with summary scores reflecting procedural knowledge routines, or the knowledge of how to perform an activity important for independent living, and executive operations, or the planning, problem solving, and execution of a plan. For example, in attempting to carry out an adaptive activity such as preparing a meal, one may need to read a recipe, follow instructions, and carry out the motor movements required; these basic cognitive and behavioral skills are referred to as procedural knowledge routines within the COALS. An individual would also need to plan, problem solve, and execute plans for preparing dinner, such as determining whether the needed ingredients are on hand and what to do if not, and deciding how to adjust plans in the event of unexpected circumstances, such as guests arriving for dinner. These skills are referred to as executive operations within the COALS. While a total score can also be calculated, the executive operations score has been shown to provide incremental validity in community outcome over and above the procedural knowledge routines score alone (McDermid Vaz et al., 2013). Given that the overarching goal in the literature is identifying key elements of predictors of community outcome, the COALS executive operations and procedural were included as separate scores.

The UPSA (Patterson et al., 2001) was administered to assess functional capacity. This performance-based measure assesses skills in five areas: ability to perform household chores, communicate, manage money and finances, use public transportation, and plan recreational activities. Scores across these skills are then summed for a total score.

Procedure. Patients participated in three assessment sessions at two time points each. During the first session, patients provided written informed consent and communicated their social and psychiatric history. Afterwards, the SCID-I/P was administered to confirm a diagnosis of either schizophrenia or schizoaffective disorder and the Positive and Negative Syndrome Scale (PANSS; Opler, Kay, Lindenmayer, & Fiszbein, 1999), a semi-structured interview assessing symptom severity, was administered. The WASI and MCCB were administered during the second assessment session and the MSIF, COALS, and UPSA were administered during the third. Finally, there were three follow-up sessions, approximately three months later, which were structured in the same manner and collected the same variables. All participants were thanked for their time and were compensated $20 for each session.

Dataset Two

Participants. Data were also obtained from a second archival dataset. This sample consisted of 157 participants with a DSM-IV confirmed diagnosis of schizophrenia or schizoaffective disorder. Recruitment strategies, exclusion criteria, and data gathering procedures were similar to the first study; however, the specific measures administered differed. Follow-up for this sample occurred 12 months after the initial set of assessments. The demographic and clinical characteristics of patients in dataset two are reported in Table 1 and educational achievement for this sample is reported in Figure 1.

Measures. Cognitive abilities in the second dataset were measured using the Wechsler Adult Intelligence Scale III (WAIS-III; Wechsler, 1997), Conners' Continuous Performance Test-II (CPT-II; Conners, 2000), and the California Verbal Learning Test-II (CVLT-II; Delis, Kramer, Kaplan, & Ober, 2000). Specifically, the WAIS-III assessed verbal ability via the Vocabulary subtest, reasoning with the Matrix Reasoning subtest, working memory with the Letter-Number Sequencing subtest, and processing speed was measured with the Symbol Search subtest. Additionally, CPT-II measured sustained attention and the CVLT-II measured verbal learning and memory. As in the first dataset, the UPSA assessed functional capacity and the MSIF was used for assessment of community outcome. Table 2 lists the measures used in each dataset.

Data Analysis

The analysis was carried out in two phases. The first part of the analysis included an EFA of the cognitive and capacity measures in datasets one and two to empirically identify the underlying factors required to complete cognitive and functional capacity tasks and determine whether separate factors are needed to represent cognitive and functional capacity tasks. First, correlation matrices and multivariate distributions were examined for each dataset. Transformations were applied as needed. Next, an EFA of the cognitive and functional capacity subscales assessed underlying common factors. Given that cognitive processes correlate substantially (Dickinson & Gold, 2008) and function as part of interconnected neural networks, an oblimin rotation was applied to reflect naturalistic processes and increase ecological validity. Additionally, best practices in EFA recommend use of oblique rotations as applying orthogonal rotations to factors that are strongly correlated results in the loss of valuable information (Costello & Osborne, 2005). Parallel analysis, factor loadings, communalities, residual correlation matrices, and root mean square residual values were inspected and informed the number of factors that best explained the data. The second part of the study evaluated how well the selected factor solutions predicted community outcome. These models were specified using structural equation modeling and, more specifically, CFA. The results of the EFA were used to inform the second part of the study by defining how variables were grouped into factors. Finally, the accepted models, along with other key predictors of outcomes (e.g., social cognition, symptoms) were evaluated for their ability to explain the variance in community outcome.

Exploratory Factor Analysis of Dataset One

Indicators of cognition in the first dataset included T-scores of the selected MCCB and WASI cognitive tests. Given that a goal of EFA is to determine how cognitive tests load on separate factors, individual MCCB tests were used instead of domain scores which are already aggregated. While use of domain scores in similar analyses is common in the literature, using domain scores restricts test scores to a preconceived notion of how the tests ought to relate to domains rather than empirically establishing underlying latent abilities. An added benefit of using performance on cognitive tests as opposed to pre-specified MCCB domains is the potential for better comparisons across studies in the literature including those which do and do not use the MCCB. The specific MCCB subtests included in the current study were: Category Fluency (animals), Brief Assessment of Schizophrenia Symbol Coding (BACS), Brief Visual Memory Test-Revised (BVMT-R), Hopkins Verbal Learning Test-Revised (HVLT-R), Letter-Number Sequencing (LNS), Neuropsychological Assessment Battery Mazes (Mazes), Spatial Span, Trail Making Test-Part A (TMT), and Continuous Performance Test – Identical Pairs (CPT-IP). As per Kern and colleagues (2011), these tests are purported to represent the following cognitive domains: processing speed, working memory, verbal learning and memory, visual learning and memory, reasoning, and attention (see Table 1). The Vocabulary subtest of the WASI was included as an indicator of verbal ability. Indicators of functional capacity included the UPSA total score and the procedural knowledge and executive operations summary scores of the COALS. Indicators of community outcome included MSIF role position, MSIF performance, and MSIF support scores.

Exploratory Factor Analysis of Dataset Two

The same statistical analyses were repeated using a second dataset with different measures. Indicators of cognition in the second dataset included T-scores from the following

WAIS-III subtests: Vocabulary, Matrix Reasoning, Letter-Number Sequencing (LNS), and Symbol Search subtests which represented verbal ability, reasoning, working memory, and processing speed domains, respectively. Category Fluency (animals) raw scores also represented processing speed,, the CPT-II *d'* T-scores were included as a measure of attention, and the CVLT-II total recall T-score represented verbal memory. Indicators of functional capacity included the UPSA summary score and indicators of community outcome included MSIF role position, MSIF performance, and MSIF support scores.

Structural Equation Modeling of Dataset One and Dataset Two

The results of the EFA for dataset one and two were used to inform which variables represented the identified factors. These models were then evaluated through CFA and SEM. The main purpose of the CFA was to represent a measurement model for cognition and functional capacity which could then be expanded to a larger SEM to evaluate how well these variables (either as a single or multiple factors) predict a community outcome factor. Several fit statistics were used to characterize model fit. The Comparative fit index (CFI) and Tucker-Lewis index (TLI) are reported; values closer to 1.0 (i.e., .9 and greater) are indicative of good fit. Root-Mean Squared Error of Approximation (RMSEA) and Standardized Root Mean Square Residual (SRMR) are reported, with values less than .08 indicating adequate fit. Determination of model fit was made by considering all fit statistics in concert.

Results

Exploratory Factor Analysis of Dataset One

Data on 13 variables across 100 patients with schizophrenia or schizoaffective disorder were first inspected for missing values. Four data points were missing, which accounted for less than 5% of the sample. Accordingly, listwise deletion reduced the sample size to $n = 96$.

Linearity of bivariate associations was assessed with pairwise scatterplots. While the bivariate relationships between most of the variables were approximately linear, relationships between most variables and the CPT-IP and LNS variables were non-linear. Accordingly, these variables were transformed with a natural logarithm function. Bivariate relationships were overall linear after these transformations were applied.

Next, a sample correlation matrix was computed to examine the bivariate relations between observed variables; see Table 3. Most of the correlations were low to moderate with the exception of a strong correlation between COALS procedural knowledge and COALS executive operations (r = .74), COALS procedural knowledge and UPSA (r = .66), and COALS executive operations and UPSA (r = .63). Additionally, there were several very weak correlations among cognitive measures (r = .04 to r = .14). The overall range of correlations indicated that there may be one or more common latent variables which explain performance across cognitive and functional capacity measures. Parallel analysis (Figure 2) suggested that a two-factor model may best explain the data.

An EFA, estimated using unweighted least squares, was conducted on the ten cognitive measures and three functional capacity indices to uncover the common factors that explain the pattern of relationships among the observed variables. Based on the sample correlation matrix, parallel analysis, theory, and hypothesis, one-factor, two-factor, three-factor, and four-factor models were estimated. An oblimin rotation was applied to multi-factor solutions. Several criteria were considered for selecting the model that best fit the data, including the root mean squared residual (RMR), communalities, residual correlations, and conceptual interpretations of the factors. The RMR for each of the solutions, communalities, residual correlations, and inter-factor correlations are presented in Tables 4 through 14.

The two-factor solution was selected as the optimal model due to clear conceptual interpretation of the factors, low RMR (RMR = .05; see Table 4 for RMR comparisons), moderate to high communalities (see Table 5), and low residual correlations (Table 6). In the two-factor solution, variables that loaded highly (i.e., .45 or greater) on the first factor appeared to reflect general cognitive abilities while the second factor appeared to represent visual processing speed and attention. The inter-factor correlation between factor 1 and factor 2 was r = .46. Several variables had moderate cross-loadings (i.e., between .35 and .45) on both factors (i.e., BACS and BVMT-R), which was consistent with the conceptual understanding of the factors and processes involved in the tasks. The other EFA models were rejected for several reasons, as outlined below.

Conceptually, a one-factor model would reflect generalized cognition. This solution was rejected due to poor RMR (RMR = .09) and low communalities. Additionally, the model did not account for several bivariate relationships (i.e., residual correlations greater than the absolute value of .10). Consequently, this model was rejected.

A three-factor solution was estimated to assess whether fit statistics might improve relative to the two-factor solution. Overall, only marginal improvements were observed in communalities, residual correlations, and RMR (RMR = .04). In the three-factor model, the pattern of factor loadings suggested that factor 1 represented functional capacity abilities and, as in the two-factor model, the two remaining factors appeared to represent visual processing and attention (factor 2), and a range of cognitive skills related to verbal processes (factor 3). Inter-factor correlations are presented in Table 11 and ranged from r = .2 to r = .58. The three-factor solution did not represent a substantial improvement over the two-factor solution and thus was rejected.

Given that a four-factor model was hypothesized, this model was also estimated. Interpretation of the pattern of factor loadings suggested that factor 1 reflected functional capacity, factor 2 represented processing speed abilities, factor 3 reflected verbal output, and factor 4 represented learning and working memory domains. Again, fit statistics did not substantially improve over a two-factor model (see Tables 12 to 14) and this solution was ultimately rejected. The two-factor solution was accepted as the model that best explained the data (see Table 5).

Exploratory Factor Analysis of Dataset Two

Data on eight variables across 157 patients with schizophrenia or schizoaffective disorder were first inspected for missing values and linear bivariate associations. Data were missing for two participants, accordingly these cases were removed through listwise deletion. Linearity was assessed with pairwise scatterplots; the bivariate relationships between variables were all approximately linear. Next, a sample correlation matrix was computed to examine the bivariate relations among observed variables (Table 15). Most correlations were low to moderate (e.g., r = .22 to r = .59) except for very weak correlations between CPT-II and all variables (r = -.17 to r = .06). The overall range of correlations indicated that there may be one or more common latent variables which explain performance across cognitive and functional capacity measures. Next, parallel analysis (Figure 3) indicated that a model with two factors best explained the data. Accordingly, a two-factor solution was estimated first. One-factor and three-factor solutions were also estimated. An EFA, estimated using unweighted least squares was conducted on the cognitive measures and functional capacity indices to uncover the underlying common factors. Oblimin rotations were applied to multi-factor solutions. Ultimately, the two-factor solution was accepted as the model that best explained the data.

The root mean squared residual for the two-factor solution was low (RMR = .04; see Table 16 for comparisons to other solutions) and factor loadings and communalities were moderate to high; see Table 17. Conceptually, variables that had higher loadings on the first factor reflected general cognitive abilities while those that loaded higher on factor two reflected processing speed. The CPT-II variable did not load highly on either factor. The communalities indicated that, with the exception of CPT-II, all variables were well-explained by the model. The correlation between factors 1 and 2 was strong, $r = .66$, and most bivariate relationships were well-explained by the model; see Table 18.

Overall, the two-factor model adequately explained the model. The root mean squared residual was in an acceptable range and the bivariate relationships among the variables were well-explained by the model. However, the communality for CPT-II was very low. Accordingly, a three-factor model was estimated. A one-factor model was estimated to assess the hypothesis that cognition and functional capacity measures are indices of one construct.

Conceptually, the one factor solution would reflect generalized cognition. The RMR for a one-factor model was adequate (RMR = 0.06). However, relative to a two-factor solution, several of the communalities were lower in this solution, including that of CPT-II; see Table 19. The residual correlation matrix for this solution revealed that several bi-variate relationships were more poorly explained by the one-factor model than the two-factor model; see Table 20. Overall, a one-factor solution was not an adequate representation of the data. A three-factor model was estimated to determine whether more factors would better explain the variance in CPT-II. However, the three-factor solution included a Heywood case (i.e., indicating the presence of a variable with a negative error variance estimate) that rendered the solution invalid.

As such, a four-factor solution was not interpreted. The two-factor solution was accepted as the model that best explained the data.

Structural Equation Modeling of Dataset One

Follow-up data used in the structural equation modeling analysis was collected 3 months after the data used for the EFA. This sample consisted of 95 of the original 100 patients; five patients were lost due to attrition. Confirmatory factor analysis was first performed to evaluate the measurement model of the accepted two-factor solution. Table 21 presents the accepted two-factor solution and indicates the measures that represented each factor. Note that tasks with factor loadings greater than .30 on more than one factor were allowed to freely cross-load in the CFA model. Fit statistics, corrected for multivariate non-normality, indicated only marginally acceptable model fit, CFI = .91, TLI = .88, RMSEA = .10, SRMR = .07, but were an improvement over the fit statistics for the one-factor and three-factor models.

Next, a structural regression model was estimated to evaluate the ability of these two factors to predict the latent variable community outcome, CFI = .91, TLI = .89, RMSEA = .08, SRMR = .07. Note that higher scores on the community outcome measure indicate greater dependency and poorer outcomes. There was a significant negative association between factor 1 (generalized cognition) and community outcome, standardized $\hat{\beta}$ = -.47, z = -2.17, $p < .05$, such that, holding factor 2 constant, community outcome is expected to improve by .47 of a standard deviation for every one standard deviation increase in generalized cognition. The association between factor 2 (visual processing speed and attention) and community outcome was very small and non-significant, standardized $\hat{\beta}$ = -.01, z = -0.03, p = .98. Covariates were added to the model one at a time due to a limited sample size. Notably, after adding education as a covariate, the association between factor 1 and community outcome became non-significant, standardized $\hat{\beta}$ = -.36, z = -1.62, p = .11. The association between education and community outcome was significant, standardized $\hat{\beta}$ = -.24, z = -2.19, $p < .05$, indicating that greater years of education were associated with better community outcome. The association between negative symptoms and community outcome was also significant, standardized $\hat{\beta}$ = .36, z = 2.55, $p < .05$, such that experiencing greater negative symptoms was associated with poorer community outcome. However, when added to the model with education, this association was no longer significant and led all other variables to also be non-significant; accordingly negative symptoms were left out of the final model. Likewise, the association between community outcome and general symptoms was initially significant, standardized $\hat{\beta}$ = .28, z = 2.24, $p < .05$, however when added to the model with education, it was no longer significant and led all other variables to be non-significant, and thus was left out of the final model. The associations between community outcome and social cognition and positive symptoms were all non-significant in this model, all *p*s > .05. Taken together, factors 1 and 2 accounted for 23% of the variance in community outcome (i.e., R^2 = .23). After adding education, the model accounted for 28 of the variance in community outcome. The final model is presented in Figure 4; correlations between exogenous variables are presented in Table 22.

Structural Equation Modeling of Dataset Two

Data for this analysis was collected during follow-up sessions 12 months after the data collected for the EFA of dataset two. This sample consisted of 128 of the original 157 patients in this sample; 27 patients were lost due to attrition. Confirmatory factor analysis was first performed to evaluate the fit of the accepted two-factor solution; however, this model did not converge. The estimated correlation between factor 1 and factor 2 was 1.015, which is illegal and suggests that factors 1 and 2 should not be separate factors. Accordingly, the two factors were combined into a generalized cognition factor and CFA was used to evaluate the one-factor solution. Robust fit statistics were very good for this solution, CFI = .97, TLI = .96, RMSEA = .06, SRMR = .04.

Next, a structural regression model was estimated to evaluate the ability of this generalized cognition factor to predict the same community outcome latent variable specified in the SEM of dataset one, CFI = .93, TLI = .91, RMSEA = .08, SRMR = .06. As noted earlier, greater values on the community outcome measure indicated poorer functioning in the community. There was a significant negative association between the generalized cognition factor and community outcome, standardized $\hat{\beta}$ = -.66, z = -4.44, $p < .001$, such that outcome is expected to improve by .66 of a standard deviation for every one standard deviation increase in generalized cognition. After adding negative, positive, and general symptoms as well as education as covariates, the association between generalized cognition and community outcome remained significant, standardized $\hat{\beta}$ = -.73, z = -4.66, $p < .001$. The association between negative symptoms and community outcome was significant, standardized $\hat{\beta}$ = -.35, z = -2.84, $p < .01$, as was the relationship between general symptoms and community outcome, standardized $\hat{\beta}$ = .34, z = 2.46, $p < .05$. The associations between education and community outcome and between positive symptoms and community outcome were not significant, all ps < .05. The generalized cognition factor accounted for 44% of the variance in community outcome (i.e., R^2 = .44). After adding education, positive, negative, and general symptoms as covariates, the overall explained variance in community outcome increased to 52%. The final model for Dataset Two is presented in Figure 5; see Table 23 for correlations between exogenous variables.

Discussion

The current study demonstrated that cognitive performance and functional capacity are indistinguishable. This finding is consistent with a large body of research demonstrating convergent validity of these instruments (e.g., Harvey et al., 2013, 2016; Leifker et al., 2011; McClure et al., 2007; Pietrzak et al., 2009) and challenges the widespread use and reporting of these measures as distinct constructs (e.g., Bowie et al., 2006, 2008; Strassnig et al., 2015). As noted earlier, the FDA has required that the efficacy of cognitively-enhancing intervention trials be demonstrated on a cognitive battery and a separate co-primary outcome measure (Buchanan et al., 2005). In light of research demonstrating no added incremental validity of functional capacity measures over cognitive measures in predicting community outcome (e.g., Heinrichs et al., 2006; Heinrichs et al., 2010; Muharib et al., 2014; Twamely et al., 2002), the current results do not support the use of both types of instruments as outcome measures in treatment evaluation studies. Instead, the results suggest the use of either functional capacity or cognitive tests as measures of clinical benefit in such studies. Moreover, the results warrant a search for a new co-primary measure. Such a measure should comply with the original guidelines which state that co-primary measures should be proxy measures of community outcome and be directly associated with (but distinct from) cognition and associated with social and occupational functioning (Buchanan et al., 2005). Measures which have the potential to meet these guidelines include variables that mediate the relationship between cognition and community outcome, such as skill acquisition abilities and social cognition.

The identification of a co-primary measure of functional improvement was previously identified as one of the most difficult agenda items by experts who sought to provide guidelines for clinical trial designs in this field (Buchanan et al., 2005) and remains a major obstacle for the development and evaluation of effective treatments. A consensus regarding a co-primary measure would allow for greater cross-study comparisons and would ultimately pave a more efficient path to understanding community outcome. Previously, the lack of consensus regarding how to measure outcome in cognitively-enhancing drug trials was highlighted as a barrier to their development and fueled the MATRICS initiative (Marder & Fenton, 2004). One outcome of this initiative was the development of a cognitive consensus battery for measuring treatment efficacy (i.e., the MCCB). Similarly, there is now a need for an agreement in the field regarding a co-primary measure in intervention studies. As noted, previously utilized functional capacity instruments are not appropriate for use as separate co-primary outcome measures. The development of a consensus of an alternate co-primary measure is a high priority due to its treatment implications.

Given that traditional cognitive and functional capacity instruments measure the same underlying abilities, experts in the field may contemplate using functional capacity measures in treatment evaluation studies instead of cognitive measures. Indeed, an advantage of using functional capacity measures includes their greater face validity and briefer length of administration relative to traditional neuropsychological measures. More specifically, administration of the MCCB ranges from 60 to 90 minutes whereas the full version of the UPSA takes approximately 45 minutes and the more newly developed UPSA-Brief takes 10 to 15 minutes to administer (Mausbach, Harvey, Goldman, Jeste, & Patterson, 2007). Additionally, functional capacity measures are easier to administer as they have fewer standardization rules around the pacing of trials, examiner responses for rule violations and errors, as well as start and discontinue rules. Accordingly, administration is less prone to administrator errors and thus such measures can more easily be administered by individuals who do not have specialized training in psychometric administration. However, traditional neuropsychological tests have decades of research supporting their development, refinement, and psychometric properties. While the administration of such measures is typically more time and training intensive than functional capacity measures, they are nonetheless well-tolerated by patients and also demonstrate minimal practice effects (Keefe et al., 2011). As noted by Marder and Fenton (2004), the determination of measures for the evaluation of efficacy in treatment trials should be based on a consensus that is grounded in robust scientific evidence rather than accepted due to convenience. A significant advantage of the MCCB is that tasks included in this battery have greater test-retest reliability than functional capacity measures (Harvey et al., 2013; Keefe et al., 2011). Notably, test-retest reliability has been deemed the most important property in the selection of measures for randomized clinical trials (Buchanan et al., 2005; Green et al., 2004b). Additionally, not only is performance on neuropsychological measures associated with community outcome, but performance on specific cognitive domains have the added value of differentially predicting performance in important life domains. Overall, the advantages of the MCCB outweigh the conveniences offered by functional capacity measures and support its designation as a primary outcome measure in cognitively-enhancing drug trials.

The current study was the first to examine the factor structure of all seven cognitive domains identified by the NIMH MATRICS expert panel (i.e., Nuechterlein et al., 2004) and it is the first to apply best practices to an exploratory factor analysis (see Costello & Osborne, 2005) in uncovering the factor structure of cognition in schizophrenia. Although the results of the analyses of dataset one and two differ slightly, they demonstrate that the seven cognitive domains identified by the expert committee are not separable into seven latent constructs. Numerous research studies have also demonstrated that the domains are not separable into seven constructs however they have varied in the number of constructs identified (e.g., Burton et al., 2006; Keefe et al., 2006;

Mohn et al., 2017). The results of the current study are most suggestive of a generalized model of cognition in schizophrenia and are most consistent with the findings of the CATIE trial (Keefe et al., 2006), which, despite using differing statistical methods and cognitive tests than the present study, concluded that a unidimensional model of cognition best explains cognitive abilities in schizophrenia. The matter of separable cognitive abilities is clinically relevant in the context of treatment studies. Indeed, one of the main objectives fueling the NIMH MATRICS initiative was the identification of cognitive domains that would be amenable to changes via pharmaceutical agents and the development of a cognitive consensus battery that could capture these changes. The resultant battery, the MCCB, was intended to identify separable cognitive abilities so that domain-specific treatment effects could be discerned. However, the current results suggest that both the MCCB and other batteries assess one generalized ability and are therefore unlikely to detect discrete changes that may be caused by pharmacological interventions. Given that mental activities rely on a complex interplay of cognitive functions and that even highly developed neuropsychological tests require input from many cognitive processes, these results are believed to reflect how cognitive functions naturally operate. Rather than viewing the limitations of extant cognitive measures as barriers to the development of effective treatments, some have proposed that results demonstrating a single generalized cognition factor suggest that pharmacological interventions are unlikely to have discrete effects on neural substrates (as reviewed in Dickinson & Gold, 2008). While advances from the cognitive neurosciences have better isolated discrete cognitive processes, they are more limited in their ability to explain functioning in the community than traditional neuropsychological tasks (Reilly & Sweeney, 2014). The current results question whether attempting to disaggregate cognitive abilities truly benefits initiatives to develop and approve cognitively enhancing treatments. Indeed, the argument that generalized, or broad, cognitive impairment is the most substantial and reliable cognitive signal in schizophrenia has been made frequently over the last four decades (Gold & Dickinson, 2013).

The current study found that almost half of the variance in community outcome can be predicted by cognition. This proportion of variance is consistent with several other studies (e.g., Keefe et al., 2006; Velligan et al., 1997) and provides additional support for cognition as a key predictor of outcomes. However, while cognition in one dataset predicted as much as 44% of variance in community outcome, the other dataset only predicted 23% of the outcome variability. Others have also noted a wide range of explained variance in community outcome from cognition, ranging from as little as 20% to as much as 60%. These results indicate that cognitive measures are not equivalent in their ability to predict community outcome. An unexpected finding of this study was that a battery of neuropsychological tests, representing the same cognitive domains as those in the MCCB, accounted for approximately 20% more variance in community outcome than the consensus battery. This finding was surprising because evidence of cognitive tasks' association with community outcome was a key and essential criterion for inclusion in the MCCB. However, review of the strength of the relationships between tests retained in the battery and community outcome revealed that these associations were moderate at best (Nuechterlein et al., 2008). Although the expert committee reviewed over 90 tests, none were rated as being strongly related to community outcome. Additionally, other factors, such as test-retest reliability and patients' ability to tolerate tasks, were factored into decisions around test retention. These results may explain why the MCCB accounted for less variance in community outcome than an alternate battery of neuropsychological tests.

These results also raise the question of what the optimal range of cognitive assessment in treatment studies should be. Indeed, numerous studies have suggested that performance on a limited battery of neuropsychological measures can account for the overall impairment in cognitive functioning (Keefe et al., 2006). While generalized impairment is a consistent finding in the literature (Gold & Dickinson, 2013), some cognitive domains provide unique exploratory power (Green, Horan, & Sugar, 2013). More specifically, there is a differential deficit in verbal memory and processing speed even in the context of a generalized cognitive deficit (Dickinson, Ragland, Gold, & Gur, 2008) and deficits in these domains are disproportionately larger than that of others (Dickinson, Bellack, & Gold, 2007; Heinrichs & Zakzanis, 1998). Consideration of differential deficits is important in the context of understanding community outcome as performance on tasks assessing these domains are expected to be more strongly related to community outcome. Ideally, selection of cognitive assessment measures should consider which tests minimize shared variance and thereby provide unique variance.

While the amount of variance predicted by the database that did not use the MCCB is remarkably consistent with that predicted by other models (e.g., Keefe et al., 2006; Velligan et al., 1997), approximately half of the variance in community outcome remained unexplained, even after the addition of social cognition, symptoms, and education as covariates. These results underscore the ongoing challenge of explaining the variance in community functioning and subsequently reducing functional disability in schizophrenia. While not typically assessed, levels of psychosocial supports and services, environmental factors, and opportunities for skill utilization are also expected to predict community functioning (Buchanan et al., 2005; Gupta, Bassett, Iftene & Bowie, 2012). Two other variables that are expected to impact community outcome include the social cognitive domains assessed (Fett et al., 2011; Mancuso et al., 2011) and the specific community outcome measures used (Leifker et al., 2011).

A notable limitation of the current study was that social cognition was represented in only one dataset. Moreover, only one aspect of social cognition was assessed (i.e., emotional intelligence) and thereby the full scope of social cognitive domains was underrepresented. While the study of social cognition in schizophrenia has a relatively shorter history compared to the assessment of non-social cognition, its association with community outcome has been deemed by some to be even more strongly related to community outcome than cognition and explain unique variance not captured by cognition (e.g., Fett et al., 2011). The omission of a broad assessment of social cognition may have substantially reduced the overall explained variance in community outcome in this study. Thus, future studies should not only seek to examine the relative contribution of social cognition in predicting community outcome, but should also include tasks which represent all four domains of social cognition (i.e., emotion processing, social perception, attribution bias, and theory of mind; Green & Horan, 2010).

An additional limitation of the current study is that the assessment of community outcome was based on one self-report measure. Notably, substantial discrepancies between self-reported functioning and informant reports have been demonstrated in the literature and the lowest correlations between community functioning and cognitive measures are found in studies employing only self-report outcome measures (Leifker et al., 2011). While the MSIF encourages the collection of data from informants such as clinicians and family members, doing so is not possible for all patients due to limited availability and resources of these informants. Nonetheless, an "entirely effective" measure of community outcome in schizophrenia has not been determined and, compared to other measures of community outcome, the MSIF is rated highly on reliability, convergence with cognitive and functional capacity measures, comprehensiveness, and practicality (Leifker et al., 2011).

Another limitation of the current study included the non-independence between patients included in the EFA analysis and those in the CFA analysis. Ideally, CFA analyses should not be conducted on the same data from which the factor structure was determined. In the case of both datasets in this study, the CFA was conducted on data collected at a second time-point which consisted of a large subset of participants who participated in the first data collection time-point. Thus, while participants were not independent, the analyses were not performed on the same data. An additional limitation was that cognitive data used in the study was not corrected for education. While education-corrected T-scores were available for the MCCB, this was not the case for other cognitive measures (e.g., WAIS-III, UPSA, COALS). Although this limitation was partially remedied by including education as a covariate, education is known to have a differential impact on cognitive tasks (e.g., has a greater influence on verbal knowledge and IQ than on some other abilities) and is also known to interact with age and gender (Brooks, Sherman, Iverson, Slick, & Strauss, 2011). Accordingly, use of education-corrected T-scores has the potential to generate different results. Given that the MCCB is recognized as a gold standard for measuring cognition in schizophrenia, this is unlikely to be an on-going limitation in future studies employing cognitive measures, however, the impact of demographic variables on performance on social cognitive and functional capacity measures will need to be determined and factored into future studies.

Conclusions

Understanding predictors of community outcome in schizophrenia continues to be a research and clinical challenge. Significant efforts have been invested into understanding and reducing functional disability in this population. One such initiative included the introduction of the concept of functional capacity, which was intended to serve as a proxy measure of functioning in the community and serve as a distinct co-primary measure alongside traditional neuropsychological tests (Buchanan et al., 2005). The purpose of this study was to assess whether the conceptualization of cognition and functional capacity as separate constructs is empirically supported. The results do not support this bifurcation and instead suggest that functional capacity tasks may be better understood as variants of standard cognitive measures that incorporate more ecologically meaningful stimulus material and performance requirements, but without evidence that this incorporation increases ecological validity. These results indicate that the use of functional capacity instruments as co-primary measures alongside neuropsychological tests is not warranted as these measures are largely redundant with one another. Consequently, alternative measures that are directly associated with cognition and community functioning will need to be reviewed for the purpose of determining a new co-primary measure. A consensus around an appropriate co-primary measure is expected to support the development of treatments aimed at improving cognition, and thereby community outcome, in schizophrenia. Researchers are also encouraged to carefully consider which cognitive tasks are included in future studies. While it is expected that differing batteries will assess a single construct of generalized cognition, they will vary in their ability to explain variance in community outcome. Lastly, the field will benefit from ongoing investigations into undiscovered predictors of community outcome to ultimately reduce the functional disability which individuals with schizophrenia endure.

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Table 1

Demographic Variables of Dataset One and Dataset Two

Demographic Variable	Dataset One (*n* = 100)	Dataset Two (*n* = 157)
Age (years), mean *(SD)*	41.66 (10.27)	40.98 (9.31)
Sex, *n* male (%)	78 (78%)	99 (63%)
Education (years), mean *(SD)*	13.02 (2.34)	-
First Language, *n* English (%)	87 (87%)	129 (82%)
Premorbid IQ* (standard score), mean *(SD)*	97.47 (15.50)	95.01 (13.79)
Age of Illness Onset (years), mean *(SD)*	22.03 (5.10)	20.83 (5.42)
PANSS Positive (T-score), mean (*SD)*	46.99 (8.07)	50.20 (5.42)
PANSS Negative (T-score), mean *(SD)*	40.84 (8.30)	45.98 (9.73)
PANSS General (T-score), mean *(SD)*	42.46 (7.22)	52.32 (9.58)

Note. Premorbid IQ was estimated using the Wide Range Achievement Test-4 Reading subtest for Dataset One and the Wide Range Achievement Test-3 for Dataset Two. Only categorical data is available for educational attainment for Dataset Two; refer to Figure 1 for details.

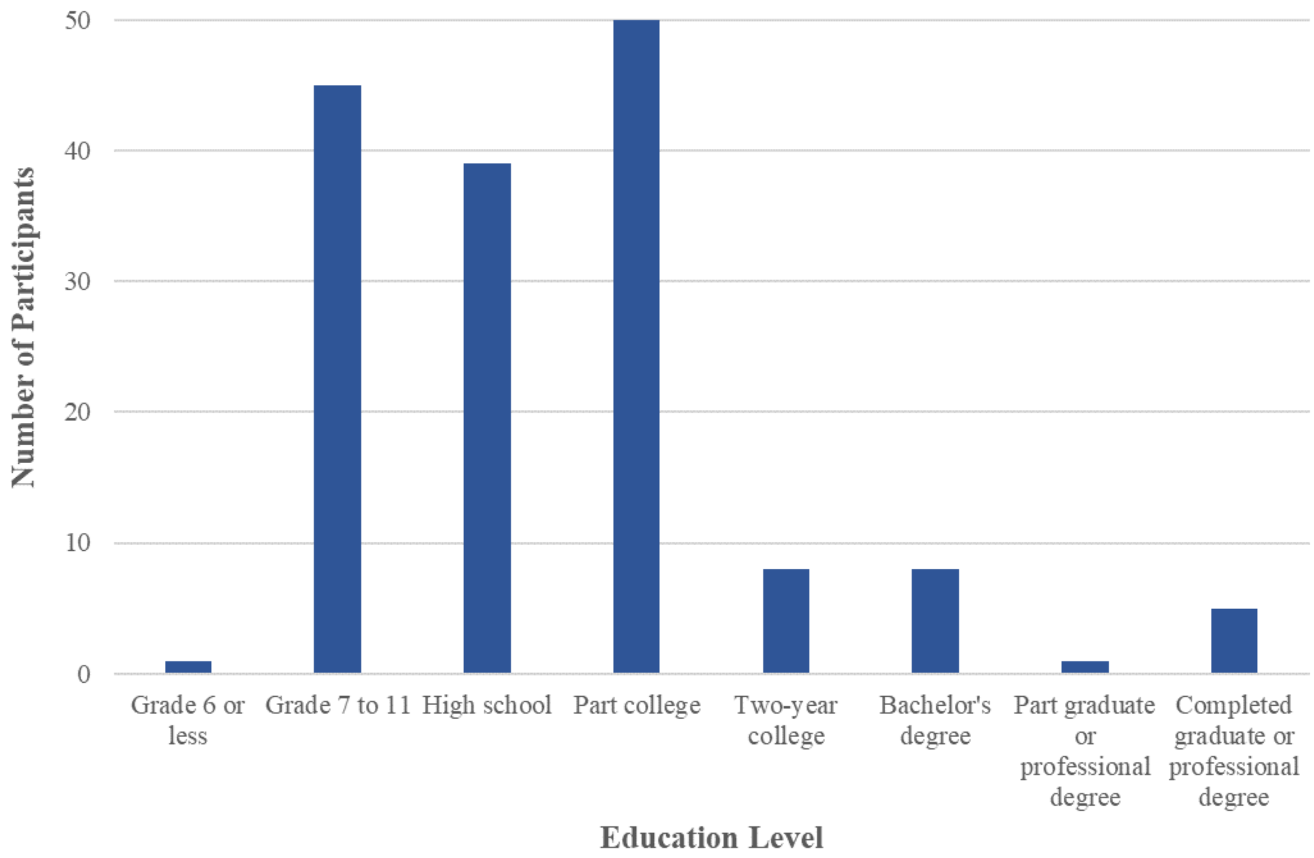

Figure 1. Frequency distribution of educational attainment of participants in dataset two

Table 2

Cognitive, Capacity, and Outcome Measures Used in Two Archival Datasets

Domain	Dataset One	Dataset Two
Verbal Comprehension		
	Vocabulary (WASI);	Vocabulary (WAIS-III);
Processing Speed		
	Trail Making Test-Part A;	Symbol Search (WAIS-III);
	Category Fluency;	Category Fluency;
	Symbol Coding (BACS);	
Attention		
	Continuous Performance Test – Identical Pairs;	Conners' Continuous Performance Test-II;
Working Memory		
	Letter-Number Span (WAIS-III); Spatial Span (WMS-III);	Letter-Number Sequencing (WAIS-III);
Verbal Memory		
	Hopkins Verbal Learning Test-Revised;	California Verbal Learning Test-II;
Visual Memory		
	Brief Visual Memory Test-Revised;	-
Reasoning		
	Mazes (NAB);	Matrix Reasoning (WAIS-III);
Functional Capacity		
	University of California San Diego Performance-Based Skills Assessment Battery total score; Canadian Objective Assessment of Life Skills: • Procedural Knowledge; • Executive Operations;	University of California San Diego Performance-Based Skills Assessment Battery total score;

Community Outcome	Multidimensional Scale of Independent Functioning: • Role Position; • Support; • Performance.	Multidimensional Scale of Independent Functioning: • Role Position; • Support; • Performance.

Note. BACS = Brief Assessment of Schizophrenia; NAB = Neuropsychological Assessment Battery; WAIS-III = Wechsler Adult Intelligence Scale III; WASI = Wechsler Abbreviated Scale of Intelligence.

Table 3

Sample Correlation Matrix between Observed Variables (Dataset One)

	Vocab	TMT	Fluency	BACS	CPT-IP	LNS	Spatial Span	HVLT-R	BVMT-R	Mazes	UPSA	COALS PRK	COALS EXO
Vocab*	1.00												
TMT*	0.07	1.00											
Fluency*	0.43	0.41	1.00										
BACS*	0.34	0.53	0.41	1.00									
CPT-IP*	0.49	0.29	0.41	0.42	1.00								
LNS*	0.27	0.22	0.35	0.42	0.41	1.00							
Spatial Span	0.14	0.41	0.30	0.39	0.32	0.28	1.00						
HVLT-R*	0.44	0.27	0.40	0.41	0.36	0.41	0.44	1.00					
BVMT-R*	0.34	0.42	0.33	0.51	0.27	0.39	0.48	0.47	1.00				
Mazes	0.04	0.59	0.30	0.43	0.30	0.34	0.49	0.29	0.36	1.00			
UPSA*	0.45	0.24	0.33	0.40	0.38	0.45	0.34	0.45	0.38	0.24	1.00		
COALS PRK*	0.56	0.40	0.39	0.55	0.54	0.43	0.41	0.55	0.45	0.37	0.66	1.00	
COALS EXO*	0.47	0.46	0.43	0.50	0.49	0.42	0.38	0.44	0.41	0.40	0.63	0.74	1.00

Note. N = 96. Vocab = Vocabulary; TMT = Trail Making Test (Part A); Fluency = Category Fluency (animals); BACS = Brief Assessment of Schizophrenia Symbol Coding; CPT-IP = Continuous Performance Test – Identical Pairs; LNS = Letter-Number Sequencing; HVLT-R = Hopkins Verbal Learning Test-Revised; BVMT-R = Brief Visual Memory Test-Revised; COALS = Canadian Objective Assessment of Life Skills; PRK = Procedural Knowledge; EXO = Executive Operations; UPSA = University of California San Diego (UCSD) Performance-Based Skills Assessment Battery.

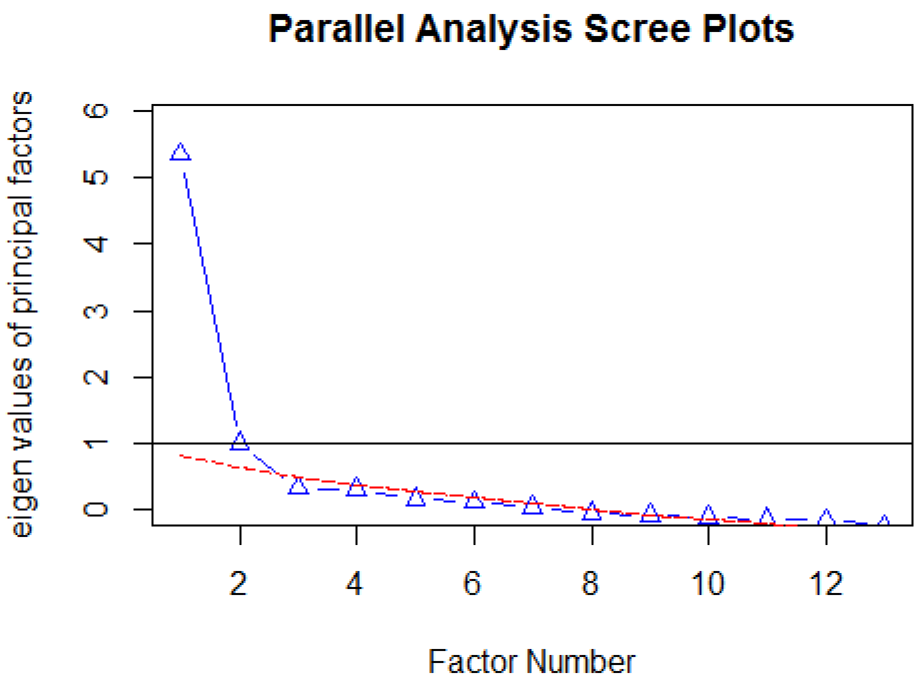

Figure 2. Parallel analysis of eigenvalues of the reduced correlation matrix (dataset one)

Table 4

Root Mean Squared Residuals of Models in Dataset One

	RMR
One-factor model	.09
Two-factor model	.05
Three-factor model	.04
Four-factor model	.03

Table 5

Oblimin-Rotated Factor Loadings and Communalities for a Two-Factor Model (Dataset One)

	Factor 1	Factor 2	Communality
Vocabulary	.83	-.29	.55
TMT*	.01	.78	.61
Fluency*	.41	.25	.32
BACS*	.39	.44	.51
CPT-II*	.57	.10	.39
LNS*	.45	.18	.31
Spatial Span	.19	.51	.39
HVLT-R*	.56	.14	.41
BVMT-R*	.35	.38	.39
Mazes	-.01	.76	.57
COALS PRK*	.74	-.02	.54
COALS EXO*	.81	.11	.75
UPSA*	.70	.20	.65

Note. TMT = Trail Making Test (Part A); Fluency = Category Fluency (animals); BACS = Brief Assessment of Schizophrenia Symbol Coding; CPT-IP = Continuous Performance Test – Identical Pairs; LNS = Letter-Number Sequencing; HVLT-R = Hopkins Verbal Learning Test-Revised; BVMT-R = Brief Visual Memory Test-Revised; COALS = Canadian Objective Assessment of Life Skills; PRK = Procedural Knowledge; EXO = Executive Operations; UPSA = University of California San Diego (UCSD) Performance-Based Skills Assessment Battery.

Table 6

Residual Correlation Matrix of a Two-Factor Solution (Dataset one)

	Vocab	TMT	Fluency	BACS	CPT-IP	LNS	Spatial Span	HVLT-R	BVMT-R	Mazes	UPSA	COALS PRK	COALS EXO
Vocab*	0.45												
TMT*	-0.01	0.39											
Fluency*	0.13	0.07	0.68										
BACS*	0.03	0.04	0.02	0.49									
CPT-IP*	0.08	0.00	0.07	0.02	0.61								
LNS*	-0.05	-0.09	0.04	0.04	0.06	0.69							
Spatial Span	-0.04	-0.06	-0.02	-0.04	0.01	-0.02	0.61						
HVLT-R*	0.04	-0.05	0.05	-0.01	-0.04	0.05	0.11	0.59					
BVMT-R*	0.06	0.00	-0.01	0.07	-0.08	0.05	0.10	0.10	0.61				
Mazes	-0.03	0.00	-0.02	-0.04	0.03	0.05	0.04	-0.01	-0.04	0.43			
UPSA*	-0.06	-0.03	-0.04	-0.03	-0.07	0.06	0.03	-0.01	0.00	0.00	0.46		
COALS PRK*	-0.01	0.01	-0.08	0.00	0.00	-0.04	0.00	-0.01	-0.04	0.01	0.03	0.25	
COALS EXO*	-0.03	0.04	-0.02	-0.04	-0.01	-0.03	-0.04	-0.08	-0.06	0.01	0.05	0.05	.35

Note. *N* = 96. Vocab = Vocabulary; TMT = Trail Making Test (Part A); Fluency = Category Fluency (animals); BACS = Brief Assessment of Schizophrenia Symbol Coding; CPT-IP = Continuous Performance Test – Identical Pairs; LNS = Letter-Number Sequencing; HVLT-R = Hopkins Verbal Learning Test-Revised; BVMT-R = Brief Visual Memory Test-Revised; COALS = Canadian Objective Assessment of Life Skills; PRK = Procedural Knowledge; EXO = Executive Operations; UPSA = University of California San Diego (UCSD) Performance-Based Skills Assessment Battery.

Table 7

Oblimin-Rotated Factor Loadings and Communalities for a One-Factor Model (Dataset One)

	Factor 1	Communality
Vocabulary	.54	.30
TMT*	.56	.31
Fluency*	.58	.34
BACS*	.70	.49
CPT-IP*	.61	.38
LNS*	.57	.33
Spatial Span	.56	.32
HVLT-R*	.65	.42
BVMT-R*	.63	.39
Mazes	.53	.29
COALS PRK*	.66	.44
COALS EXO*	.82	.68
UPSA*	.78	.61

Note. TMT = Trail Making Test (Part A); Fluency = Category Fluency (animals); BACS = Brief Assessment of Schizophrenia Symbol Coding; CPT-IP = Continuous Performance Test – Identical Pairs; LNS = Letter-Number Sequencing; HVLT-R = Hopkins Verbal Learning Test-Revised; BVMT-R = Brief Visual Memory Test-Revised; COALS = Canadian Objective Assessment of Life Skills; PRK = Procedural Knowledge; EXO = Executive Operations; UPSA = University of California San Diego (UCSD) Performance-Based Skills Assessment Battery.

Table 8

Residual Correlation Matrix of a One-Factor Solution of the Data (Dataset One)

	Vocab	TMT	Fluency	BACS	CPT-IP	LNS	Spatial Span	HVLT-R	BVMT-R	Mazes	UPSA	COALS PRK	COALS EXO
Vocab*	0.70												
TMT*	-0.23	0.69											
Fluency*	0.12	0.09	0.66										
BACS*	-0.04	0.14	0.01	0.51									
CPT-IP*	0.15	-0.05	0.05	-0.01	0.62								
LNS*	-0.04	-0.10	0.02	0.02	0.05	0.67							
Spatial Span	-0.17	0.09	-0.03	-0.01	-0.03	-0.05	0.68						
HVLT-R*	0.09	-0.09	0.02	-0.04	-0.04	0.04	0.07	0.58					
BVMT-R*	-0.01	0.07	-0.03	0.07	-0.11	0.03	0.12	0.07	0.61				
Mazes	-0.25	0.29	-0.01	0.06	-0.03	0.03	0.19	-0.05	0.03	0.71			
UPSA*	0.09	-0.13	-0.05	-0.07	-0.03	0.07	-0.04	0.02	-0.04	-0.12	0.56		
COALS PRK*	0.11	-0.06	-0.09	-0.03	0.03	-0.04	-0.06	0.01	-0.07	-0.07	0.12	0.32	
COALS EXO*	0.05	0.02	-0.03	-0.05	0.01	-0.03	-0.06	-0.07	-0.08	-0.02	0.11	0.10	.39

Note. *N* = 96. Vocab = Vocabulary; TMT = Trail Making Test (Part A); Fluency = Category Fluency (animals); BACS = Brief Assessment of Schizophrenia Symbol Coding; CPT-IP = Continuous Performance Test – Identical Pairs; LNS = Letter-Number Sequencing; HVLT-R = Hopkins Verbal Learning Test-Revised; BVMT-R = Brief Visual Memory Test-Revised; COALS = Canadian Objective Assessment of Life Skills; PRK = Procedural Knowledge; EXO = Executive Operations; UPSA = University of California San Diego (UCSD) Performance-Based Skills Assessment Battery.

Table 9

Oblimin-Rotated Factor Loadings and Communalities Values for the Exploratory Factor Analysis of a Three-Factor Model (Dataset One)

	Factor 1	Factor 2	Factor 3	Communality
Vocabulary	.40	-.21	.56	.64
TMT*	.08	.75	-.10	.61
Fluency*	.05	.35	.39	.37
BACS*	.17	.51	.23	.52
CPT-IP*	.36	.14	.26	.40
LNS*	.23	.25	.23	.31
Spatial Span	.03	.57	.14	.40
HVLT-R*	.15	.27	.46	.47
BVMT-R*	-.02	.51	.38	.46
Mazes	.06	.74	-.11	.57
COALS PRK*	.75	-.06	.05	.55
COALS EXO*	.82	.05	.07	.79
UPSA*	.85	.10	-.10	.74

Note. TMT = Trail Making Test (Part A); Fluency = Category Fluency (animals); BACS = Brief Assessment of Schizophrenia Symbol Coding; CPT-IP = Continuous Performance Test – Identical Pairs; LNS = Letter-Number Sequencing; HVLT-R = Hopkins Verbal Learning Test-Revised; BVMT-R = Brief Visual Memory Test-Revised; COALS = Canadian Objective Assessment of Life Skills; PRK = Procedural Knowledge; EXO = Executive Operations; UPSA = University of California San Diego (UCSD) Performance-Based Skills Assessment Battery.

Table 10

Residual Correlation Matrix of a Three-Factor Solution of the Data (Dataset One)

	Vocab	TMT	Fluency	BACS	CPT-IP	LNS	Spatial Span	HVLT-R	BVMT-R	Mazes	UPSA	COALS PKR	COALS EXO
Vocab*	0.36												
TMT*	0.01	0.39											
Fluency*	0.07	0.08	0.63										
BACS*	0.00	0.04	-0.01	0.48									
CPT-IP*	0.05	0.01	0.05	0.01	0.60								
LNS*	-0.07	-0.09	0.02	0.03	0.06	0.69							
Spatial Span	-0.05	-0.06	-0.04	-0.05	0.01	-0.03	0.60						
HVLT-R*	-0.02	-0.04	-0.02	-0.04	-0.06	0.03	0.09	0.53					
BVMT-R*	0.00	0.00	-0.08	0.03	-0.10	0.03	0.07	0.04	0.54				
Mazes	0.00	0.00	-0.01	-0.03	0.04	0.05	0.04	0.00	-0.04	0.43			
UPSA*	-0.04	-0.04	-0.01	-0.02	-0.06	0.08	0.04	0.03	0.03	-0.01	0.44		
COALS PKR*	0.00	0.00	-0.05	0.01	0.00	-0.02	0.01	0.03	0.00	0.00	0.01	0.21	
COALS EXO*	0.01	0.02	0.03	-0.01	0.00	-0.01	-0.02	-0.02	0.00	-0.01	0.01	-0.01	.26

Note. *N* = 96. Vocab = Vocabulary; TMT = Trail Making Test (Part A); Fluency = Category Fluency (animals); BACS = Brief Assessment of Schizophrenia Symbol Coding; CPT-IP = Continuous Performance Test – Identical Pairs; LNS = Letter-Number Sequencing; HVLT-R = Hopkins Verbal Learning Test-Revised; BVMT-R = Brief Visual Memory Test-Revised; COALS = Canadian Objective Assessment of Life Skills; PKR = Procedural Knowledge; EXO = Executive Operations; UPSA = University of California San Diego (UCSD) Performance-Based Skills Assessment Battery.

Table 11

Inter-factor Correlations within the Three-Factor Model (Dataset One)

	Factor1	Factor 2	Factor 3
Factor 1	1.00		
Factor 2	.54	1.00	
Factor 3	.58	.20	1.00

Table 12

Oblimin-Rotated Factor Loadings and Communality Values for the Exploratory Factor Analysis of a Four-Factor Model (Dataset One)

	Factor 1	Factor 2	Factor 3	Factor 4	Communality
Vocabulary	.09	-.05	.85	.01	.83
TMT*	.05	.86	-.01	.02	.79
Fluency*	-.06	.36	.43	.16	.41
BACS*	.16	.36	.16	.27	.51
CPT-IP*	.27	.15	.32	.08	.40
LNS*	.30	-.06	.00	.38	.34
Spatial Span	.09	.13	-.13	.60	.48
HVLT-R*	.11	-.08	.21	.57	.53
BVMT-R*	-.04	.17	.16	.56	.49
Mazes	.13	.46	-.19	.30	.52
COALS PRK*	.77	-.16	-.02	.12	.60
COALS EXO*	.75	.04	.11	.07	.78
UPSA*	.81	.18	.04	-.10	.74

Note. N=96. TMT = Trail Making Test (Part A); Fluency = Category Fluency (animals); BACS = Brief Assessment of Schizophrenia Symbol Coding; CPT-IP = Continuous Performance Test – Identical Pairs; LNS = Letter-Number Sequencing; HVLT-R = Hopkins Verbal Learning Test-Revised; BVMT-R = Brief Visual Memory Test-Revised; COALS = Canadian Objective Assessment of Life Skills; PRK = Procedural Knowledge; EXO = Executive Operations; UPSA = University of California San Diego (UCSD) Performance-Based Skills Assessment Battery.

Table 13

Residual Correlation Matrix of a Four-Factor Solution of the Data (Dataset One)

	Vocab	TMT	Fluency	BACS	CPT-IP	LNS	Spatial Span	HVLT-R	BVMT-R	Mazes	UPSA	COALS PRK	COALS EXO
Vocab*	0.17												
TMT*	0.00	0.21											
Fluency*	0.00	0.01	0.59										
BACS*	-0.01	0.00	-0.01	0.49									
CPT-IP*	0.01	-0.02	0.03	0.02	0.60								
LNS*	-0.02	-0.03	0.07	0.06	0.09	0.66							
Spatial Span	0.00	-0.01	0.00	-0.04	0.04	-0.08	0.52						
HVLT-R*	0.00	0.01	0.03	-0.02	-0.04	0.00	0.01	0.47					
BVMT-R*	0.01	0.02	-0.05	0.04	-0.08	0.01	0.02	0.00	0.51				
Mazes	0.00	0.00	0.00	-0.02	0.05	0.05	0.05	-0.02	-0.04	0.48			
UPSA*	0.00	0.01	0.03	-0.01	-0.04	0.04	0.00	-0.01	0.01	-0.03	0.40		
COALS PRK*	0.00	0.00	-0.05	0.02	0.01	-0.03	0.00	0.02	-0.01	0.00	0.00	0.22	
COALS EXO*	0.00	0.00	0.02	-0.02	0.00	0.00	0.00	-0.01	0.00	0.00	0.01	0.00	.26

Note. *N* = 96. Vocab = Vocabulary; TMT = Trail Making Test (Part A); Fluency = Category Fluency (animals); BACS = Brief Assessment of Schizophrenia Symbol Coding; CPT-IP = Continuous Performance Test – Identical Pairs; LNS = Letter-Number Sequencing; HVLT-R = Hopkins Verbal Learning Test-Revised; BVMT-R = Brief Visual Memory Test-Revised; COALS = Canadian Objective Assessment of Life Skills; PRK = Procedural Knowledge; EXO = Executive Operations; UPSA = University of California San Diego (UCSD) Performance-Based Skills Assessment Battery.

Table 14

Inter-factor Correlations within the Four-Factor Model (Dataset One)

	Factor1	Factor 2	Factor 3	Factor 4
Factor 1	1.00			
Factor 2	.61	1.00		
Factor 3	.42	.49	1.00	
Factor 4	.58	.35	.08	1.00

Table 15

Sample Correlation Matrix between Observed Variables (Dataset Two)

	Vocab	LNS	Matrix	Symbol Search	CVLT-II	Fluency	CPT-II	UPSA
Vocab*	1.00							
LNS*	0.59	1.00						
Matrix*	0.51	0.55	1.00					
Symbol Search	0.36	0.47	0.47	1.00				
CVLT-II*	0.45	0.48	0.48	0.40	1.00			
Fluency*	0.36	0.22	0.30	0.45	0.30	1.00		
CPT-II*	-0.16	-0.07	-0.16	-0.05	-0.12	0.06	1.00	
UPSA*	0.57	0.51	0.41	0.38	0.42	0.33	-0.17	1.00

Note. *N* = 155. Vocab = Vocabulary; LNS = Letter-Number Sequencing; Matrix = Matrix Reasoning; CVLT-II = California Verbal Learning Test-II; Fluency = Category Fluency (animals); CPT-II = Conners' Continuous Performance Test-II; UPSA = University of California San Diego (UCSD) Performance-Based Skills Assessment Battery.

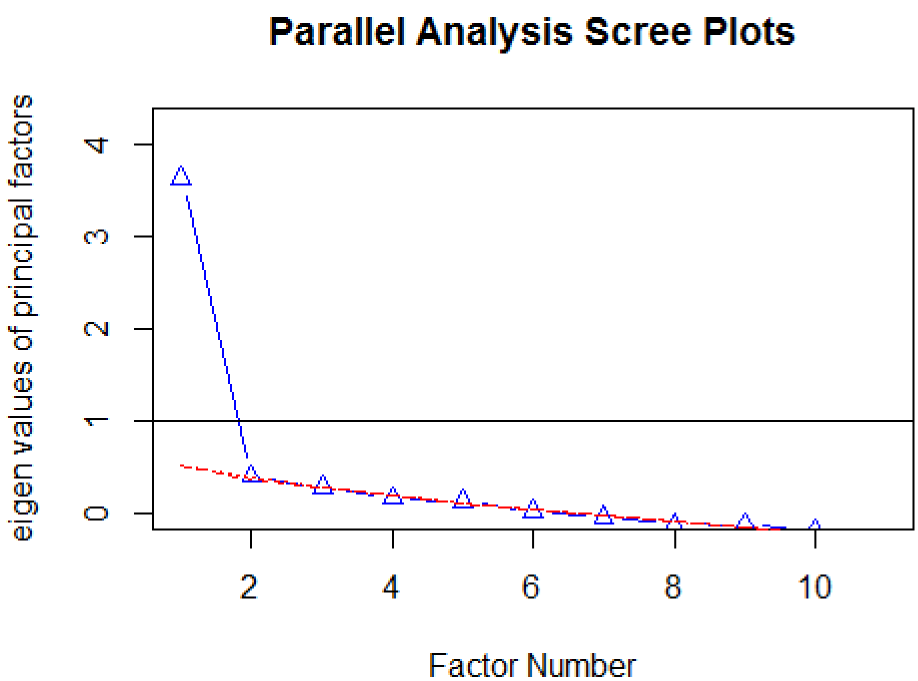

Figure 3. Parallel analysis of eigenvalues of the reduced correlation matrix (dataset two)

Table 16

Root Mean Squared Residuals of Models in Dataset Two

	RMR
One-factor model	.06
Two-factor model	.04

Table 17

Factor Loadings and Communalities for the Two-Factor Model (Dataset Two)

	Factor 1	Factor 2	Communality
Vocabulary	.80	-.05	.60
Letter Number Sequencing	.78	-.01	.59
Matrix Reasoning	.59	.16	.49
Symbol Search	.15	.63	.54
CVLT-II	.52	.15	.40
Category Fluency	-.05	.66	.40
CPT-II	-.35	.24	.07
UPSA	.67	.03	.47

Note. N = 155. CVLT-II = California Verbal Learning Test-II; CPT-II = Conners' Continuous Performance Test-II; UPSA = University of California San Diego (UCSD) Performance-Based Skills Assessment Battery

Table 18

Residual Correlation Matrix of a Two-Factor Solution (Dataset Two)

	Vocab	LNS	Matrix	Symbol Search	CVLT-II	Fluency	CPT-II	UPSA
Vocab*	0.41							
LNS*	0.00	0.41						
Matrix*	-0.01	0.02	0.51					
Symbol Search	-0.05	0.05	0.03	0.46				
CVLT-II*	-0.03	0.00	0.04	-0.01	0.60			
Fluency*	0.07	-0.08	-0.03	0.00	0.00	0.60		
CPT-II*	0.00	0.08	-0.05	-0.02	-0.02	0.05	0.93	
UPSA*	0.05	-0.01	-0.06	-0.01	-0.01	0.05	-0.05	0.53

Note. N = 155. Vocab = Vocabulary; LNS = Letter-Number Sequencing; Matrix = Matrix Reasoning; CVLT-II = California Verbal Learning Test-II; Fluency = Category Fluency (animals); CPT-II = Conners' Continuous Performance Test-II; UPSA = University of California San Diego (UCSD) Performance-Based Skills Assessment Battery.

Table 19

Factor Loadings and Communalities for the One-Factor Model (Dataset Two)

	Factor 1	Communality
Vocabulary	.75	.57
Letter Number Sequencing	.76	.57
Matrix Reasoning	.70	.49
Symbol Search	.61	.37
CVLT-II	.64	.40
Category Fluency	.45	.20
CPT-II	-.16	.03
UPSA	.68	.46

Note. N = 155. CVLT-II = California Verbal Learning Test-II; CPT-II = Conners' Continuous Performance Test-II; UPSA = University of California San Diego (UCSD) Performance-Based Skills Assessment Battery.

Table 20

Residual Correlation Matrix of a One-Factor Solution (Dataset Two)

	Vocab	LNS	Matrix	Symbol Search	CVLT-II	Fluency	CPT-II	UPSA
Vocab*	0.44							
LNS*	0.03	0.43						
Matrix*	-0.01	0.02	0.51					
Symbol Search	-0.09	0.02	0.04	0.63				
CVLT-II*	-0.03	0.00	0.03	0.01	0.60			
Fluency*	0.02	-0.12	-0.01	0.18	0.01	0.80		
CPT-II*	-0.04	0.05	-0.05	0.05	-0.01	0.13	0.97	
UPSA*	0.06	0.00	-0.07	-0.03	-0.01	0.02	-0.06	0.54

Note. N = 155. Vocab = Vocabulary; LNS = Letter-Number Sequencing; Matrix = Matrix Reasoning; CVLT-II = California Verbal Learning Test-II; Fluency = Category Fluency (animals); CPT-II = Conners' Continuous Performance Test-II; UPSA = University of California San Diego (UCSD) Performance-Based Skills Assessment Battery.

Table 21

Measurement Model of Factor Loadings for the Accepted Two-Factor Solution (Dataset One)

	Generalized Cognition	Visual Processing Speed and Attention
Vocabulary	.83	
Fluency*	.41	
CPT-IP*	.57	
LNS*	.45	
HVLT-R*	.56	
COALS PRK*	.74	
COALS EXO*	.81	
UPSA*	.70	
BVMT-R*	.35	.38
BACS*	.39	.44
TMT*		.78
Spatial Span		.51
Mazes		.76

Note. TMT = Trail Making Test (Part A); Fluency = Category Fluency (animals); BACS = Brief Assessment of Schizophrenia Symbol Coding; CPT-IP = Continuous Performance Test – Identical Pairs; LNS = Letter-Number Sequencing; HVLT-R = Hopkins Verbal Learning Test-Revised; BVMT-R = Brief Visual Memory Test-Revised; COALS = Canadian Objective Assessment of Life Skills; PRK = Procedural Knowledge; EXO = Executive Operations; UPSA = University of California San Diego (UCSD) Performance-Based Skills Assessment Battery.

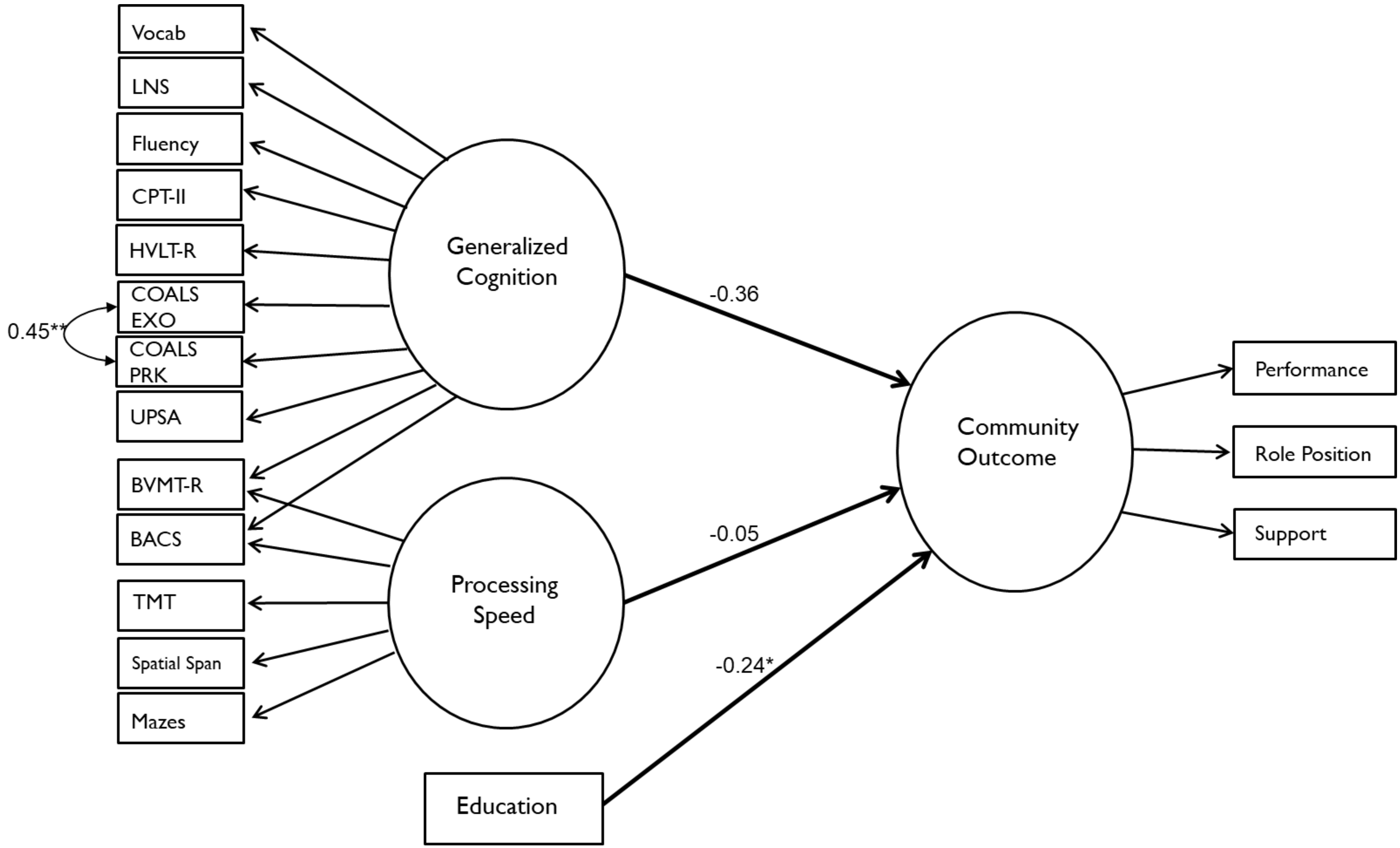

Figure 4. Community outcome prediction model of dataset one
Model fit: CFI = .90, TLI = .88, RMSEA = .08, SRMR = .07; R^2 = .28; * = $p < .05$

Table 22

Correlations Between Exogenous Variables in Dataset One

	Generalized Cognition	Processing Speed
Generalized Cognition		
Processing Speed	.73**	
Education	.34*	.16

Note. *N* = 95; * = $p \leq .05$; ** = $p \leq .001$

Table 23

Correlations Between Exogenous Variables in Dataset Two

	Generalized Cognition	Education	Positive Symptoms	Negative Symptoms
Education	.42**			
Positive Symptoms	-.19*	-.06		
Negative Symptoms	-.34**	-.14*	.01	
General Symptoms	-.36**	-.13	.52**	.50**

Note. *N* = 157; * = $p \leq .05$; ** = $p \leq .00$

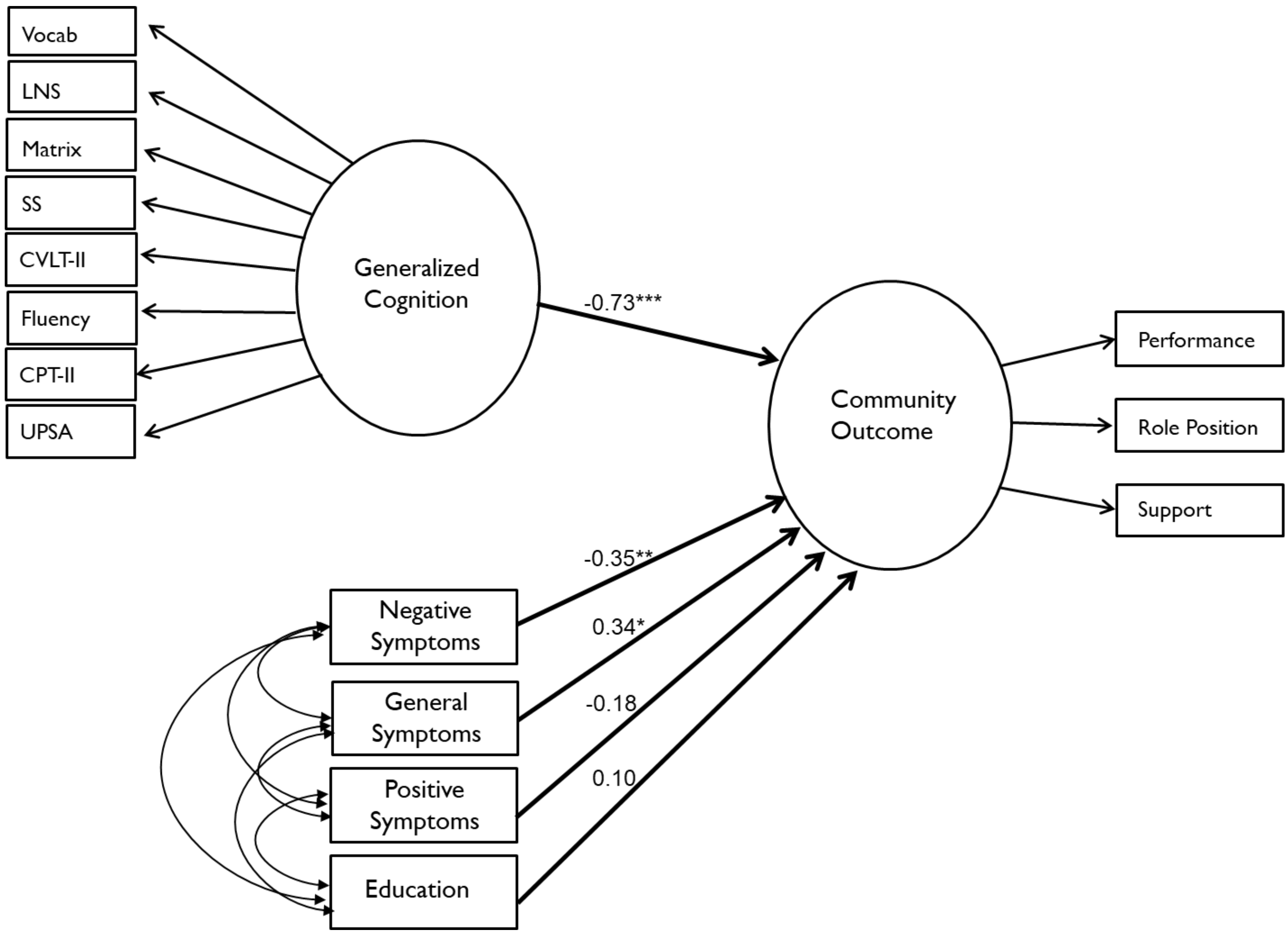

Figure 5. Community outcome prediction model of dataset two
Model fit: CFI = .90, TLI = .86, RMSEA = .07, SRMR = .06; R^2 = .52; * = $p \leq .05$; ** = $p \leq .01$; *** = $p \leq .001$