“Formal Thought Disorder” in Homeless Young Adults with Elevated Schizotypal Traits: Dimensional Structure and Cognitive Correlates

Cliff Deyo (BA, GDipSocSci - Psych, BSocSci - Hons, MA)

Department of Psychology

Faculty of Human Sciences

Macquarie University

Empirical thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Psychology (Clinical Neuropsychology), Macquarie University, submitted March 31, 2015.

TABLE OF CONTENTS

TABLE OF TABLES

PAPER 1

PAPER 2

General Abstract

Background and Aims: The primary aims were to investigate the dimensional structure and cognitive underpinnings of formal thought disorder (FTD) using the continuum approach. Positive and negative FTD dimensions (PFTD and NFTD) have been distinguished by different cognitive relationships in patients with schizophrenia, but inconsistency in findings may relate to patient-related confounds. The continuum approach of investigating schizophrenia symptoms is free of patient-related confounds, but its suitability to FTD research is uncertain.

Method: We performed principal components analysis (PCA) of FTD ratings using the Scale for the Assessment of Thought, Language and Communication (TLC) and the Thought and Language Index (TLI) in a sample (N = 92 and 89, respectively) of homeless young adults with elevated schizotypal traits. Cognitive correlates of the PCA-derived TLC/TLI components were investigated using a comprehensive neuropsychological battery; and we examined whether TLC/TLI components were differentiated by their cognitive relationships.

Results: The TLC and TLI showed "clinically-elevated" communicative disturbances. PCA described a three-component TLC solution ("Disorganisation", "Verbosity", "Emptiness") and two-component TLI solution ("Negative", "Idiosyncratic"), generally consistent with schizophrenia research. TLC "Disorganization" and "Emptiness" ratings, but not TLI ratings, correlated with psychosis-like experiences. Language/semantic and higher-order reasoning dysfunction appeared to drive TLC Disorganisation; while higher-order reasoning and executive dysfunction were the strongest determinants of TLI Negative. Contributions of cognitive dysfunction to TLI Idiosyncratic and TLC Emptiness were less clear; and these were not substantially differentiated from TLC Disorganisation or TLI Negative by their cognitive relationships. *Stronger* cognitive functioning within this sample, predicted TLC Verbosity, related principally to executive and language/semantic functioning.

Conclusion: FTD is associated with schizotypal traits in the general population; FTD is multidimensional in persons with elevated schizotypal traits; language/semantic and higher-order reasoning dysfunction appear to drive PFTD; NFTD primarily relates to higher-order reasoning/executive dysfunction; and the continuum approach to FTD research is supported.

Declaration

The research reported in this thesis is my original work. It has not been submitted for a higher degree in any other university or institution. Formal ethics approval was obtained from the Macquarie University Human Ethics Committee prior to commencement of the current research: Final approval reference number 5201001263. The research reported in this thesis was conducted under the supervision of my principal supervisor, Associate Professor Robyn Langdon.

_____

Cliff Deyo

Acknowledgement

This thesis is the culmination of a five year project that was undertaken as a partial requirement of a Doctor of Psychology (Clinical Neuropsychology) at Macquarie University. I would like to acknowledge the contribution of my principal supervisor, Associate Professor Robyn Langdon, who provided invaluable professional support and guidance over the period of the project. As well, Associate Professor Peter Petocz contributed expert advice on statistical matters.

General Introduction

Disturbances of form of speech, such as changing the topic of conversation disjointedly, paucity of speech, and incoherence are characteristic of schizophrenia (American Psychiatric Association, 2013); and collectively these are referred to as *formal thought disorder* (FTD). The term originates from psychiatry, which sought to distinguish abnormalities of *content* of thought (e.g., delusions) from peculiarities of the *form* of thought, as revealed through speech. FTD is usually regarded as having both *positive FTD* (PFTD) and *negative FTD* (NFTD) dimensions in patients with schizophrenia. PFTD refers to abnormalities of unusual presence of atypical forms of speech, such as responding obliquely or incoherently; while NFTD principally consists of reduced speech output and markedly vague speech that is empty of meaningful content. Kraepelin (1919/trans.1999) hypothesized that FTD was a consequence of cognitive dysfunction; and this continues to be a leading theory. Consequent to evidence linking cognitive deficits with FTD (Kerns & Berenbaum, 2002), there is a focus on developing cognitive models to explain FTD and inform psychological intervention. The need for this is suggested by research linking poorer psychosocial functioning with FTD in patients with schizophrenia (for review, see Roche, Creed, MacMahon, Brennan, & Clarke, 2014); and evidence indicating FTD as a prominent predictor of transition to psychosis in high-risk samples (Bearden, Wu, Caplan, & Cannon, 2011; Demjaha, Valmaggia, Stahl, Byrne, & McGuire, 2012; DeVylder, Muchomba, Gill, Ben-Davida, et al., 2014; Wilcox, Briones, Quadri, & Tsuang, 2014).

Some variability of findings may relate to patient-related factors, such as medication effects. To address this concern, the *continuum approach* to researching schizophrenia symptoms is free of patient-related confounds, as relationships of interest to schizophrenia symptoms are investigated in non-clinical samples with attenuated schizophrenia-like traits, or *schizotypal* traits (for discussion, see Persons, 1986). However, the suitability of the

continuum approach to FTD research is uncertain: Some evidence links elevated schizotypal traits with objectively-rated communication disturbance in undergraduate samples (Coleman, Levy, Lenzenweger, & Holzman, 1996; Minor & Cohen, 2010), but not all studies report this relationship (Weinstein, McKay, & Ngan, 2008). Another potential source of variability in the neuropsychological findings relates to differences in how studies have operationalized FTD: Some research investigates relations with a global measure of FTD (Stirling, Hellewell, Blakeley, & Deakin, 2006); and others investigate relationships with dimensions of FTD (e.g., PFTD and NFTD), as these have been shown to be differentiated by different patterns of cognitive dysfunction (Barch & Berenbaum, 1996; Berenbaum, Kerns, Vernon, & Gomez, 2008). The broad aims of this investigation are to investigate the underlying dimensionality of FTD in a general-community sample with elevated schizotypal traits; and to examine the relationship between cognition and FTD in this sample. This research first provides an introductory overview of findings from FTD research, with a focus on research from patients with schizophrenia. This review also emphasizes findings from research that index FTD using the Scale for the Assessment of Thought, Language, and Communication (TLC, Andreasen, 1978), as the TLC was used in the present investigations and is the most commonly used tool to index FTD. Two empirical investigations follow the general introduction, and these address the main aims stated above. Following the studies, is a section that summarizes the findings, and examines how the findings from the two studies relate to each other.

This research was undertaken to contribute to knowledge regarding the underlying dimensional structure of FTD, the cognitive underpinnings of FTD, and cognitive models on which psychological interventions can be based. Findings may also inform the suitability of the continuum approach to FTD research.

Measuring FTD by Objective Rating Scale

Scale for the Assessment of Thought, Language, and Communication.

The usual approach to indexing FTD in clinical practice and research settings, is by rating scales of interviews or other speech samples, of which the Scale for the Assessment of Thought, Language, and Communication (TLC, Andreasen, 1978) is the most commonly used tool (for discussion, see McKenna & Oh, 2005). Reflecting the clinical descriptive-psychopathological tradition (Musalek, Larach-Walters, Lepine, Millet, & Gaebel, 2010), the TLC provides clear definitions, exemplars, and rating criteria for 18 subtypes of FTD. Each subtype is rated according to observed frequency or intensity during an interview (usually 45 minutes, or prorated accordingly) centered on questions relating to the respondent's attitudes, beliefs, and experiences: In our research these included, "Why do you think that people believe in God?", and "What do you think should be done about terrorism?". The TLC reflects Andreasen's (1986) belief that FTD is better conceptualized as dysfunction of thought, language, and communication abilities, rather than solely as disorganization of thought. Accordingly, TLC items *poverty of speech* and *illogicality* index absence of thought and aberrant inferential processes, respectively (Andreasen, 1986). Next, the language abnormality items include *incoherence, clanging, neologisms,* and *word approximations*; and are believed to reflect deviations from conventions governing syntax and semantics. Finally, are those items relating to inefficient communication, such as may occur when a speaker fails to follow conventions of communication that assist a listener's comprehension: *poverty of content of speech, pressure of speech, distractible speech, tangentiality, derailment, stilted speech, echolalia, self-reference, circumstantiality, loss of goal, perseveration,* and *blocking* (Andreasen, 1978).

Thought and Language Index and other rating scales.

The Thought and Language Index (Liddle, 1995) was developed to provide a means of measuring more subtle FTD, such as may occur in non-clinical individuals with elevated schizotypal traits (Coleman, et al., 1996; Minor & Cohen, 2010); and non-clinical individuals who experience auditory verbal hallucinations (I. E. Sommer et al., 2010). The TLI's eight items correspond conceptually to FTD subtypes from the TLC; and FTD is indexed while the participant describes pictures or performs other structured tasks. Of potential utility to continuum-design research, its structured format may limit potential confounds relating to interpersonal factors on FTD. The concern raised is that social anhedonia has been linked with schizotypal traits in general-community samples; and is regarded to be a core feature of schizotypy (Blanchard, Collins, Aghevli, Leung, & Cohen, 2011; Horan, Brown, & Blanchard, 2007). In addition, the TLI operationalizes poverty of speech using a word count to a structured task which may make it relatively sensitive to subtle impoverishment of speech. Also of methodological concern, there is considerable variability in how FTD is operationalized across rating scales, in part reflecting differing perspectives on the fundamental nature of FTD. So, it has been recommended that research investigating the cognitive correlates of FTD use multiple scales to ensure breadth of coverage of FTD (Roche, et al., 2014). Other scales used to rate deviancy of speech include the Thought Disorder Index (TDI, Johnston & Holzman, 1979; Solovay et al., 1986), and the Communication Disturbances Index (Docherty, DeRosa, & Andreasen, 1996). More recently, the Thought and Language Disorder scales were developed to index objective and subjective FTD (T. Kircher et al., 2014).

FTD Dimensionality

There is general agreement that FTD as it is observed in patients with schizophrenia is best described as having a multidimensional structure (for discussion, see Roche, et al.,

2014); and FTD is usually regarded as having two syndromes, referred to as *positive FTD* (PFTD) and *negative FTD* (NFTD). A distinction between PFTD and NFTD is reflected in the description of schizophrenia provided by the Diagnostic and Statistical Manual of Mental Disorders-V (American Psychiatric Association, 2013). It specifies disorganized speech (i.e., PFTD) as belonging to the broad category of "positive symptoms" (along with delusions and hallucinations); and *alogia* (i.e., reduction of the amount of speech, an aspect of NFTD) as contributing to "negative symptoms", along with symptoms of affective flattening and avolition. Support exists for PFTD and NFTD dimensions experimentally and conceptually (for review, see Cuesta & Peralta, 1999); and both have been shown to associate with conceptually-related symptoms in schizophrenia (Walker & Harvey, 1986). For example, Liddle (1987) performed factor analysis of individual symptoms from the Comprehensive Assessment of Symptoms and History (Andreasen, 1987) in patients with schizophrenia, and found that PFTD clustered with symptoms of inappropriate affect on a Disorganization factor; while *poverty of speech* loaded with symptoms of decreased spontaneous movement and blunting of affect on a Psychomotor Poverty factor. FTD did not contribute to a Reality Distortion syndrome comprised of *delusions* and *hallucinations*. Grube, Bilder, and Goldman (1998) pooled and performed PCA on data from 10 factor analytic studies of symptoms of inpatients with chronic schizophrenia; and found a similar structure. Similarly, Smith, Mar, and Turoff (1998) pooled data from 28 studies and tested four models using confirmatory factor analysis: Liddle's model provided the best fit to the data.

Factor analytic research and FTD Dimensionality.

However, evidence from factor analytic research indicates that the underlying structure of FTD may be more nuanced than a simple positive-negative dichotomy. These investigations use statistical techniques such as principal components analysis (PCA) to reduce the items on a FTD rating scale to a fewer number of components, referred to as

factors by convention, that are each comprised of related and intercorrelated items (for discussion, see Tabachnick & Fidell, 2001). Nearly all of the research investigating the underlying factor structure of FTD in patients with schizophrenia has employed the TLC. Overall, these studies describe three generally reliable dimensions, usually labelled as Disorganisation, Emptiness/Negative, and either Verbosity or Linguistic Control that account for about 40 to 65% of the variance (Andreasen, 1979; Andreasen & Grove, 1986; Andreou et al., 2008; Bazin, Lefrere, Passerieux, Sarfati, & Hardy-Bayle, 2002; Berenbaum, Oltmanns, & Gottesman, 1985; Cuesta & Peralta, 1999, 2011; Harvey et al., 1992; Nagels et al., 2013; Ott, Roberts, Rock, Allen, & Erlenmeyer-Kimling, 2002; Peralta, Cuesta, & De Leon, 1992; Taylor, Reed, & Berenbaum, 1994). However, when FTD models have been compared using confirmatory factor analysis the findings have been mixed. For example, Harvey et al. examined four models using eight of the more reliable TLC items; and found support for Berenbaum, Oltmanns, and Gottesman's two-factor model comprising Verbal Productivity and Disconnection. Cuesta and Peralta (1999) tested nine models using 18 TLC items; and described a best-fitting six-factor model: Disorganization, Negative, Idiosyncratic, Semantic, Attentional, and Referential. In summarising the factor analytic research, Roche et al. (2014) described three principal factors: a well-defined Disorganisation factor, comprised of *tangentiality*, *derailment*, *incoherence*, *illogicality*, *circumstantiality*, and *loss of goal*; a Negative factor, including *poverty of content of speech*, *poverty of speech*, and sometimes *perseveration*; and a Verbosity or Linguistic Control factor, characterised by *pressure of speech* and *poverty of speech*, that have opposite loadings.

Some concerns regarding the underlying dimensionality of FTD remain to be clarified. One of these is reconciling how a person may demonstrate both *poverty of speech* and vagueness of content despite adequate quantity of speech (i.e., *poverty of content of speech*), (McKenna & Oh, 2005), as both are often thought to contribute to a Negative factor (Roche,

et al., 2014). Contributing to this complexity, some research indicates that *poverty of content of speech* may contribute to both a PFTD and NFTD factor in patients with schizophrenia: For example, Harvey et al. (1992) reported small correlations between *poverty of content of speech* and *poverty of speech*; and moderate correlations between *poverty of content of speech* and FTD subtypes contributing to a PFTD dimension (*tangentiality, derailment, incoherence, circumstantiality,* and *loss of goal*). Other likely sources of variability across these studies include differences in sample age, diagnostic heterogeneity, clinical status, reliability of symptoms (McKenna & Oh; Roche, et al.), and statistical concerns, including decision criteria for the number of factors to retain in factor analysis (T. Kircher, et al., 2014).

A Concise Review of FTD Research

While FTD is typically associated with schizophrenia (Roche, et al., 2014), FTD may occur in mania, schizoaffective disorder and psychotic and non-psychotic depression (Andreasen, 1979; Andreasen & Grove, 1986; Holzman, Shenton, & Solovay, 1986; Makowski et al., 1997; Shenton, Solovay, & Holzman, 1987; Solovay, Shenton, & Holzman, 1987). The prevalence of clinically-elevated FTD as indexed using the TLC (i.e., TLC Global > 1) has been reported to be 68% in schizophrenia, 76% in mania, and 60% in schizoaffective disorder (Andreasen & Grove); and it is important to note that like other symptoms of schizophrenia, FTD is not present in all patients. The prevalence of FTD is greater in early-onset (age ≤ 44 years, mostly 16-25 years) than late-onset non-organic psychosis (age ≥ 45 years): PFTD 27.4% versus 10.4%, and NFTD 11.0% versus 2.2%, respectively (Howard, Castle, Wessely, & Murray, 1993). FTD is also elevated in groups without a DSM-V Axis-I psychotic illness, including, schizotypal personality disorder (SPD, Caplan, Perdue, Tanguay, & Fish, 1990; Dickey et al., 2003), attention-deficit/hyperactivity disorder (Caplan, Guthrie, Tang, Nuechterlein, & Asarnow, 2000), and autism spectrum disorders (Gaag, Caplan, Engeland, Loman, & Buitelaar, 2005; Rumsey, Andreasen, & Rapoport, 1986). FTD may

also be elevated in clinically-unaffected biological relatives of patients with schizophrenia (Docherty & Gordinier, 1999; Docherty, Gordinier, Hall, & Cutting, 1999; Gooding et al., 2010; Ott, et al., 2002); and increasing severity of FTD in parents of probands with schizophrenia has been associated with greater severity of illness in the patients (Docherty, et al.). Sex also appears to influence FTD, as FTD has been reported to be greater in males than females (Moser, Cienfuegos, Barros, & Javitt, 2001; Pandurangi, Sax, Pelonero, & Goldberg, 1994). As FTD is found in a diverse range of clinical and non-clinical groups, it follows that it is unlikely that there is a single cognitive or other cause of all FTD; and that FTD in different groups may be distinguishable by qualitative differences.

Qualitative differences in FTD between diagnoses.

Different diagnoses are distinguishable to a degree by qualitative differences in FTD (for discussion, see Levy et al., 2010): For example, FTD in mania has been distinguished from FTD as it occurs in schizophrenia: FTD in patients with mania was distinguished by more elevated TLC *pressure of speech, distractibility,* and *circumstantiality*; and FTD in patients with schizophrenia demonstrated greater TLC *poverty of content of speech* and *poverty of speech* (Andreasen, 1979; Andreasen & Grove; for review, see also McKenna & Oh, 2005). Along this line, the TLC has been shown to correctly classify 91% of patients with schizophrenia from patients with mania, as *poverty of speech* and disorganized speech occurred more frequently in patients with schizophrenia, and *pressure of speech* was more prevalent in patients with mania (Taylor, et al., 1994). Some research indicates that FTD in schizoaffective disorder and schizophrenia is qualitatively similar (Andreasen & Grove, 1986; Holzman, et al., 1986; Shenton, et al., 1987; Solovay, et al., 1987). Depression may be characterized by elevated NFTD (TLC *poverty of speech* and *poverty of content of speech*), and by *circumstantiality*, *tangentiality*, and *self-reference* (Andreasen). It follows from these findings indicating heterogeneity of FTD across diagnoses that the aetiology of FTD also

varies by diagnosis; and that heterogeneity of samples across studies may account for some variability of neuropsychological findings.

The course of FTD.

The course of FTD varies by diagnosis (for review, see Roche, et al., 2014). During the acute phase of a disturbance, most patients with schizophrenia or mania experience severe FTD (Harrow, Marengo, & McDonald, 1986; Marengo & Harrow, 1985); and FTD during this period is more likely in patients with schizophrenia who also had cognitive deficits (Harrow, et al., 1986). In patients with mania, FTD is likely to remit following the acute phase; and in patients with schizoaffective disorder there is lesser improvement (Andreasen & Grove, 1986; Harrow & Marengo, 1986). In patients with schizophrenia, the acute phase is followed by partial reduction of PFTD over the next few months, but many patients continue to experience PFTD during this period (Harrow, Grossman, Silverstein, & Meltzer, 1982). It has been reported that of patients with psychotic illness who experienced FTD during the acute phase, about 31% of patients with schizophrenia demonstrated severe FTD at 1.5 year follow-up, compared to 13% of patients with other psychotic illness: For patients with schizophrenia, when severe FTD was present at 1.5 year follow-up, this usually occurred (77% of cases) within the context of continuing illness and poor functioning, rather than as reoccurrence of an acute disturbance (15% of cases, Harrow, et al., 1986). Worsening of PFTD has been reported in patients with schizophrenia (Maeda et al., 2007); although other evidence indicates improvement at 10- and 20-year reassessment: NFTD tends to be persistent (Wilcox, Winokur, & Tsuang, 2012). Response of FTD to treatment may relate more to executive function than semantic abilities: Goldstein et al. (2002) reported that better executive function and larger frontal lobe volume, as well as younger age and higher verbal IQ were associated with reduced severity of FTD following initial stabilization of symptoms

in patients with first-episode schizophrenia and schizoaffective disorder; but semantic competency and temporal lobe volume were unrelated to improvement of FTD.

FTD in childhood and adolescence, and progression to psychosis.

Although characteristic symptoms of psychosis (delusions, hallucinations) typically emerge during the period from late adolescence to early adulthood (Hafner et al., 1994; Jones, 2013; Kessler et al., 2007), elevated FTD may be evident during childhood in persons at genetic risk of psychosis, many years before clinical illness presents; and this may be particularly true of NFTD (Gooding, Ott, Roberts, & Erlenmeyer-Kimling, 2013; Ott, et al., 2002). Along this line, Metsänen et al. (2004) found that Thought Disorder Index ratings of 0.5 at initial assessment predicted psychiatric disorder among low-genetic risk adoptees at a median follow-up of 12 years, OR = 2.7 (95% CI = 1.2 – 5.9, p = .02). Bearden, Wu, Caplan and Cannon (2011) reported that greater severity of *illogical thinking* and *poverty of content* predicted conversion to psychosis at approximately one year among adolescents at high-risk for psychosis: *illogical thinking* was able to predict 69% of converters and 71% of non-converters; and greater severity of *poverty of content* was related to poorer social functioning. Similarly, DeVylder et al. (2014) found that elevated FTD at baseline predicted psychosis in individuals at clinical-high-risk several years later. Also, FTD during late adolescence/early adulthood has been shown to predict schizotypal traits in mid-adulthood, and subsequent development of psychosis (Gooding, et al., 2010).

Parental communication deviance.

Parental communication disturbances have been linked to progression to psychosis among their offspring. Recent meta-analytic research indicates a strong reliable link (d = .79, p = .007, N = 7 studies) between a parent's reduced ability to sustain focused attention during conversation (*communication deviance*) and diagnosis of schizophrenia spectrum disorder in their offspring; as well as a possible relationship between parental communication deviance

and increasing severity of FTD in their offspring (Roisko, Wahlberg, Miettunen, & Tienari, 2014). This study was not able to determine whether these relationships reflected genetic or environmental factors, as most of the research examined was cross-sectional and included biological relatives of the patients. However, using an adoption method to investigate environmental and genetic influences on FTD and diagnosis of schizophrenia spectrum disorders, Roisko, Wahlberg, Hakko, and Tienari (in-press) found that of several risk factors, only elevation of the adoptive parents' communication deviance was associated with increasing severity of FTD in a sample of adopted children at high and low genetic risk for schizophrenia spectrum disorders: FTD in the adoptees was unrelated to their genetic risk of schizophrenia spectrum disorders, winter or spring birth, or their interactions. None of the risk factors investigated in their analysis was predictive of diagnosis of schizophrenia spectrum disorders. In reviewing the evidence, Roisko, Wahlberg, Hakko, and Tienari suggested that it is likely that parental communication deviance impairs cognitive development among children who are biologically vulnerable, increasing the likelihood of FTD in this subgroup, independent of the effects of shared genetic vulnerability. If they are correct, and parental communication deviance does gives rise to cognitive impairment and FTD in biologically vulnerable children, it suggests that therapeutic intervention aimed at remediating aspects of communication among these parents may be a candidate strategy to protect against transition to psychosis.

Functional implications of FTD.

The presence of elevated FTD may have functional implications, as greater severity of FTD has been linked to poorer psychosocial functioning (Gilbert, 2015), work performance (Racenstein, Meg, Penn, Harrow, & Schleser, 1999), social engagement, social skills, friendships, and other psychosocial factors in various clinical groups (Bowie & Harvey, 2008; Köther et al., 2012; for review, see Roche, et al., 2014; Ruhrmann, Schultze-Lutter,

Salokangas, & et al., 2010; T. Smith et al., 1999). Bearden, Wu, Caplan and Cannon (2011) found that *poverty of content* and social functioning at baseline accounted for 36% of the variance in social functioning at one year follow-up. Poorer outcome has been linked with residual PFTD in patients with schizophrenia (Harrow & Marengo, 1986). Andreasen and Grove (1986) examined FTD in patients with schizophrenia, schizoaffective disorder, and mania over a six-month period following admission, and found that prominent NFTD, but not PFTD, was related to poorer functioning on follow-up as indicated by the Global Assessment Scale (Endicott, Spitzer, Fleiss, & Cohen, 1976).

The relationship between elevated FTD and poorer social functioning may reflect direct effects of disorganized or reduced speech on the ability to communicate with others; and concomitant neurocognitive and *social cognitive* dysfunction (e.g., difficulty comprehending the thoughts, perceptions, and emotions of others) may mediate or moderate this relationship (Docherty et al., 2013). Consider for example, the adverse effect that a severe reduction in speech would likely have on friendships and other social bonds. Also, disorganized speech and poverty of speech would make it difficult to have one's needs understood by others: For example, communication disturbances would make it difficult for clinicians to gather information pertinent to making treatment decisions (e.g., adjusting medication in light of side effects) and responding to risk (e.g., suicide ideation; threats from others). Neurocognitive and social cognitive deficits in these patients may further impact domains of functioning requiring verbal expression: For instance, memory deficits might interfere with thinking of things to say during a conversation, or with recalling important details regarding side effects during a visit to a physician; and difficulty understanding the thoughts of another person, may result in incongruent responses to questions and a loss of a sense of 'connectedness'. Some research has attempted to tease apart the relationships between FTD, cognition, and social functioning. In a longitudinal investigation, Bowie and Harvey (2008)

found that increasing severity of NFTD (*verbal underproductivity*) and PFTD (*disconnected speech*) were related to poorer communication, conversation, social skills, and adaptive behaviours in older patients with schizophrenia. In addition, NFTD and PFTD were differentially related to different functional domains: NFTD was associated with social withdrawal and fewer friendships, while PFTD was related to socially disruptive behaviour. These differential relationships were also apparent in the regression analyses at 2.5 year follow-up. In addition, FTD was related primarily to social-interpersonal behaviours, while cognitive functioning was related to instrumental adaptive behaviours, including adaptive communication behaviours (e.g., telephone use and written correspondence). Overall, this suggests that FTD is more strongly related to poorer social functioning, whereas cognitive dysfunction is more directly related to impaired adaptive behaviours. Similarly, Bowie, Gupta, and Holshausen (2011) found that FTD contributed to predicting social functioning even after controlling for cognitive functioning, clinical symptoms, and course of illness. Tan, Thomas, and Rossell (2014) investigate relationships between FTD, cognitive function, and objective and subjective functioning in patients with schizophrenia or schizoaffective disorder: They found that poverty of speech was shown to independently predict impaired social and daily functioning independent of the effects of cognitive dysfunction and depression. The authors suggested that reduced spontaneous communication disrupts social relations; and that therapy to increase verbal production may improve social engagement.

Cognitive Models of FTD

Cognitive theories of FTD in patients with schizophrenia that have the most replicable supporting evidence to date, include two formulations: The first implicates higher-order executive dysfunction, the second posits disturbances of semantic systems. *Executive function* refer to higher-order mental capacities that contribute to more complex thought and behavior, such as adapting to novel complex situations, pursuing goals while avoiding interference (*set*

maintenance/response inhibition), monitoring and adjusting performance, planning, manipulating information held in mind (*working memory*), and mental flexibility (*set shifting*): although the operationalization of executive function is a matter of debate (Alvarez & Emory, 2006). Working memory deficits have been posited to cause incoherent speech, because to produce coherent speech, one must be able to hold online a discourse plan that one has generated (Berenbaum, et al., 2008), and monitor and correct errors while speaking (McGrath, 1991). Along this line, it has been posited that inability to make, monitor and edit a speech plan may cause perseveration and distractibility (Barch & Berenbaum, 1996; McGrath). McGrath proposed that a dissociation between "knowing and doing", such as is sometimes reported in patients with pre-frontal lobe damage, may result in failure to execute a speech plan. Planning deficits have also been proposed to underlie NFTD (Barch & Berenbaum, 1997). A factor that must be addressed by models that posit speech planning deficits, is how to account for the hypothesized effects of decreased planning on speech, given that speech normally occurs without conscious formulation; subjectively, speech is experienced as an automatic activity (Goldberg et al., 1998).

Other executive dysfunction hypotheses that have been proposed to account for FTD include, difficulty *establishing set* for speech (i.e., being less ready to respond in a particular way) as a cause of *poverty of speech* and *poverty of content*; distractibility, as a cause of *tangentiality*, *derailment* and *loss of goal*; and inability to attend to a new topic (i.e., *switch set*), as a cause of *perseveration* (McGrath, 1991). The *reality monitoring hypothesis* (Rochester, 1978) proposes that information processing dysfunction, such as affecting the storage of sensory cues when speaking, causes uncertainty as to whether information held in mind relates to previous speech, or the current discourse plan leading to FTD.

Semantic memory refers to the durable store of knowledge of concepts, word meanings, operational schemas, and information of the world that is without reference to time, person,

or place (Binder, Desai, Graves, & Conant, 2009; Squire, 2004). A model of semantic memory represents units of semantic knowledge as nodes in a web-like system. These nodes are connected to nodes that are semantically-related, such that once a node is activated, related nodes are also activated; and the degree of activation of a node corresponds to the strength of relatedness between nodes (Collins & Loftus, 1975): For example, reading the word HAMMER would strongly activate the concept NAIL, as these concepts are closely related semantically. The *spreading-activation hypothesis* proposes that FTD is caused by increased spreading of activation which may narrow the differential strength of activation of associated nodes, result in greater persistence of activation, or activate less-related nodes, giving rise to distantly-related or unrelated associations in speech (Kiang, 2010; Levine, Schild, Kimhi, & Schreiber, 1996; Mohr, Graves, Gianotti, Pizzagalli, & Brugger, 2001; Reilly, Harrow, Tucker, Quinlan, & Siegel, 1975; R. Sommer, Dewar, Osmond, & Sask, 1960). The *disorganisation hypothesis* postulates that FTD results from aberrant organization of semantic information (Goldberg, et al., 1998).

Cognitive Correlates of FTD

In this regard, neuropsychological evidence consistently links higher-order executive dysfunction and impaired processing of semantic information with FTD in patients with schizophrenia (Kerns & Berenbaum, 2002); and dysfunction of other domains of cognition have also been related to FTD in patients with schizophrenia, including slowed information processing (Stirling, et al., 2006), impaired vigilance/sustained attention (Harvey & Pedley, 1989), reduced attention span, memory dysfunction, reduced language abilities, and impaired higher-order reasoning (Berenbaum, et al., 2008). Evidence associating cognitive dysfunction with FTD in patients with schizophrenia is generally consistent with neuropsychological research of cognitive functioning in patients with schizophrenia that reliably describes cognitive deficits to low-level information processing, processing speed, attention, language,

learning and episodic memory, and executive function (Heinrichs & Zakzanis, 1998; Park & Gooding, 2014; Seidman et al., 2015; Stone & Hsi, 2011; Yeo et al., 2014). The following are a review of findings from studies that investigated relations between cognitive functions and different FTD subtypes as indexed using the TLC.

Focusing first on the role of executive functioning, McGrath, Scheldt, and Hengstberger (1997) investigated relations between each of the separate abilities of establishing, maintaining, and shifting set and each of PFTD, NFTD and *perseveration* at two times (within days following acute admission, and 4 weeks later) in a sample of patients with schizophrenia and bipolar mania. In summary, increasing severity of NFTD was associated with poorer verbal fluency performance at Time 1; and fewer *categories achieved* on the Wisconsin Card Sorting Task (Heaton, 1981) at Time 2. PFTD was inversely related to Stroop performance at Time 1 and 2; and Trails B-A score at Time 2. Increasing severity of *perseveration* was related to fewer *categories achieved* on the Wisconsin Card Sorting Task, poorer Stroop performance, and Wisconsin Card Sorting Task *perseverative errors* at Time 2 only. The evidence provided some support for the hypotheses that impaired ability to maintain set during interference is related to PFTD; impaired ability to establish set is related to NFTD; and set shift dysfunction is linked with severity of perseveration. Regarding possible explanations for the inconsistent patterns of relationships between the two test periods, some studies have reported different patterns of relationships between cognitive dysfunction and FTD in samples of patients with schizophrenia than in patient groups with mania (Harvey, 1985; Harvey, Earle-Boyer, & Levinson, 1988; Harvey, Earle-Boyer, Wielgus, & Levinson, 1986; Harvey & Serper, 1990). Also, some evidence indicates that medication status associates with FTD severity, cognitive function, and relationships between cognitive function and FTD (Harvey & Pedley, 1989; Stirling, et al., 2006). Along this line, a second study using data from the same sample as reported above by McGrath, Scheldt, and

Hengstberger, reported that the pattern of improvement between the two test phases differed according to diagnosis (schizophrenia versus bipolar mania, McGrath, Scheldt, Welham, & Clair, 1997). These findings suggest that medication status, diagnosis or their interaction may account for some of the variability in findings between the two time periods. Of note, this evidence is also important for identifying possible sources of variability across neuropsychological studies.

Goldberg et al. (1998) went beyond the role of executive function to explore the relationship between attention, working memory, and semantic functioning and each of PFTD and NFTD in patients with schizophrenia. When high and low FTD groups were compared on the cognitive battery, only fluency difference score (category fluency minus letter fluency) indexing selective semantic deficits, distinguished the groups. The groups were not differentiated by performance on measures of attention, working memory, or naming. In the regression analysis, fluency difference score and fund of receptive vocabulary together accounted for 43% of the variance of PFTD, whereas no combination of cognitive variables accounted for more than 10% of the variance in NFTD score. Also, zero-order correlations indicated no relationships between the cognitive variables and NFTD. Overall, these findings indicate evidence suggesting disruption of some aspect of semantic functioning contributes to PFTD, but not NFTD.

Barch and Berenbaum (1996) investigated the relation between language production processes and individual subtypes of FTD in patients with schizophrenia and schizoaffective disorder. The findings indicated support for the hypothesis that FTD subtypes are distinguished from each other by their relationships with different facets of language production. Specifically, poorer picture arrangement (which they used to index poor discourse planning) was associated with increasing severity of *incompetent references*; this relationship was stronger than the relationships between picture arrangement and each of the

other FTD subtypes: *neologisms-word approximations*, *derailment-non-sequitur responses*, and *tangential responses*. Also grammatical-phonological encoding was inversely related to *neologisms-word approximations*; and this relationship was distinguished from the relationships between grammatical-phonological encoding and either *derailment-non-sequitur responses* or *tangential responses*. Increasing difficulty with speech monitoring was associated with *derailment-non-sequitur responses*. *Tangential responses* were not related to any of the language production measures. This study is significant for providing neuropsychological evidence indicating that FTD is multidimensional.

Berenbaum et al. (2008) examined relationships between attention, language, memory, and executive functioning and different subtypes of FTD in patients with schizophrenia and schizoaffective disorder. They reported three FTD subtypes *discourse coherence* (TLC *tangentiality*, *derailment*, and *loss of goal*; and nonsequitur responses), *verbosity* (the number of words spoken), and *syntactic complexity*. The cognitive battery was comprised of measures purported to index attention/concentration (repeating digits forward), word finding, fluency (composite of category, letter and design fluency tasks), episodic memory, working memory, and planning. They found that poorer word finding, episodic memory, working memory, and planning (a composite of picture and sentence arrangement tasks) were associated with greater disturbance of *discourse coherence*; and poorer attention/concentration, fluency, and planning were associated with diminished *verbosity*. Of note, working memory performance was more strongly related to *discourse coherence* than with *verbosity*; and *discourse coherence* and *verbosity* were distinguished by their different patterns of relationships with the cognitive variables. For example, *discourse coherence* was related more strongly with working memory than attention/concentration or fluency; while *verbosity* was more strongly related to fluency than working memory ability. This investigation is significant for demonstrating that different aspects of FTD are differentiated

by different patterns of cognitive dysfunction, as was similarly reported by Barch and Berenbaum (1996). As well, this study adds to the evidence associating FTD with dysfunction of language production (specifically word finding). In this regard, previous research has found that the evidence indicating a relationship between disturbances of language production and FTD is mixed (Kerns & Berenbaum, 2002): Some evidence links increasing severity of word-finding difficulty with FTD in patients with schizophrenia (Stirling, et al., 2006), but not all studies report this association (Blakey, Hellewell, & Deakin, 1996; Goldberg, et al., 1998; Rodriguez-Ferrera, McCarthy, & McKenna, 2001). Some of this inconsistency may relate to effects of chronicity of illness and effects of medication.

Brain Structure and Functional Correlates of FTD

Structural abnormality to brain regions contributing to language processing and production have been linked to FTD in patients with schizophrenia; and preliminary evidence links different patterns of brain structural abnormality with different FTD subtypes. Among this evidence, magnetic resonance imaging (MRI) region-of-interest analyses have reported negative associations between left posterior superior temporal gyrus (STG) volume and FTD (Rajarethinam, DeQuardo, Nalepa, & Tandon, 2000; Shenton et al., 1992; Subotnik, Bartzokis, Green, & Nuechterlein, 2003). Also, voxel-based morphometric analysis has revealed links between reduced volume of the left posterior STG, left posterior temporal sulcus, anterior cingulate gyrus bilaterally, left angular gyrus, precuneus bilaterally, right cuneus and orbitofrontal cortex, and left temporal pole and TLC-rated FTD (Horn et al., 2009). Subsequently, Horn et al. (2010) reported inverse associations between TLC-rated FTD and reduced grey-matter volume within the right middle orbital gyrus, right cuneus lingual gyrus, left temporal pole, and left superior temporal sulcus inferior to the planum temporale. The planum temporale is thought to play a role in lexical storage (Gagnepain et al., 2008); while the

left temporal pole contributes to semantic processing (Patterson, Nestor, & Rogers, 2007). Sans-Sansa and colleagues (2013) found that PFTD and NFTD were differentially related to different patterns of regional volume loss: PFTD was negatively associated with left STG and inferior operculum grey-matter volume, to regions approximating Broca's and Wernicke's areas, respectively. NFTD (*poverty of content of speech*) was associated with medial frontal and orbitofrontal cortex bilaterally, regions purported to contribute to speech output. An important task is to account for structural change given FTD's variable course that may include remission (Sans-Sansa, et al.).

FTD in patients with schizophrenia has been linked with dysfunction of left frontal and temporoparietal lobe regions that contribute to language functioning in functional imaging studies (Horn, et al., 2009); and FTD has associated with reduced left lateralisation of activation of language areas (T. T. Kircher et al., 2002). In line with this, temporal lobe and prefrontal regions associated with language and executive function have been shown to demonstrate increased presynaptic striatal dopaminergic activity, altered neural activity, and reduced grey matter volume in high-risk and schizophrenia cohorts (Fusar-Poli, 2012; Levitt, Bobrow, Lucia, & Srinivasan, 2010; Takahashi et al., 2009). In comparison, persons with elevated schizotypal traits who do not transition to schizophrenia have been shown to have lower levels of FTD and striatal dopamine, and greater frontal cortex volume, indicating possible protective factors (for review, see Siever & Davis, 2004).

Overall, the imaging research provides important converging evidence associating FTD in patients with schizophrenia with executive dysfunction and impaired language processing, in that the imaging findings link FTD with abnormality to structures and functional systems associated with executive function and language processing; and preliminary evidence links different FTD subtypes with different patterns of structural abnormality, which accords with neuropsychological research (e.g., linking PFTD specifically with volume reductions to

regions associated with language/semantic processing). Together, evidence from the imaging and neuropsychological research may have significant implications for treatment: They identify promising targets for cognitive remediation and pharmacotherapy (e.g., executive dysfunction and semantic processing); and suggest that treatment may differentially impact different FTD subtypes according to the cognitive domain targeted for intervention.

Schizotypy

Now I turn to the construct of schizotypy before reviewing schizotypy research. Schizotypy relates conceptually to the continuum model of psychosis (Claridge, 1994) that posits clinical psychosis symptoms as distributed on a continuum of severity extending into the general population with varying levels of schizotypal traits (Johns & van Os, 2001). Support for the continuum model includes research reporting that many people in the general community who are without clinical psychotic illness report subclinical psychosis-like experiences (Neuvo et al., 2012; van Os, Linscott, Myin-Germeys, Delespaul, & Krabbendam, 2009). Further support for the continuum model includes evidence of neuroanatomical, cognitive, genetic and other similarity between persons with elevated schizotypal traits and clinical individuals with schizophrenia (Nelson, Seal, Pantelis, & Phillips, 2013). The continuum model has two principal formulations. The *quasi-dimensional model* originating from the work of Meehl (1962) posits a gene that carries liability to schizophrenia; and is otherwise expressed as schizotypy in a specific group referred to as *schizotypes*. The second formulation, the *fully-dimensional model*, postulates schizotypy as a set of biologically-based traits that are expressed in the normal population to variable degree (Claridge, 1985; Claridge & Davis, 2003). These formulations have been investigated empirically; and a dominant model is yet to emerge (Beauchaine, Lenzenweger, & Waller, 2008; Rawlings, Williams, Haslam, & Claridge, 2008). Many self-report inventories are available to index schizotypal traits (for discussion, see Bentall, Claridge, & Slade, 1989).

Continuum FTD research.

The suitability of the continuum approach to FTD research using general-community samples is uncertain. Preliminary evidence links elevated schizotypal traits with objectively-rated communication disturbance in undergraduate samples (Coleman, et al., 1996; Minor & Cohen, 2010) and with self-reported communication disturbance (Gooding, Tallent, & Hegyi, 2001), but this relationship is not reported by all studies (Weinstein, et al., 2008). Stress appears to disorganize speech, but this relationship is not specific to schizotypy: It has been reported in samples with elevated schizotypal traits (Kerns & Becker, 2008), and samples with relatively low levels of schizotypal traits (Minor & Cohen). However, stress-induced communication disturbances may relate to the cognitive disturbances that associate with schizotypy: In undergraduate samples with elevated schizotypal traits (but not in those with low levels of such traits), greater severity of stress-induced communication disturbance has been related to poorer working-memory performance (Kerns & Becker, 2008) and greater atypical sequencing of category items (Minor, Cohen, Weber, & Brown, 2011). Preliminary evidence also links raised communication disturbances with aberrant visual context processing in undergraduates with elevated schizotypal traits (Uhlhaas, Silverstein, Phillips, & Lovell, 2004). To date, no study has examined the underlying dimensional structure of FTD in a general-community sample with psychometrically-elevated schizotypal traits; and to our knowledge, there is no research that has used the continuum approach to investigate the cognitive profile of objectively-rated FTD, in particular, those profiles associated with different dimensions of FTD.

The Present Research Program

Following on from the General Introduction, this research program seeks to contribute to understanding the underlying dimensional structure of FTD; and to add to knowledge regarding the possible cognitive underpinnings of FTD. To do this, the research uses the

continuum-approach and a neuropsychologically-informed methodology. The suitability of the continuum approach to FTD research is uncertain.

Paper 1 examines the dimensional structure of FTD in a general-community sample of homeless young adults with psychometrically-elevated schizotypal traits that excluded DSM-V Axis I psychotic disorder and confounds related to antipsychotic medications and institutionalization. Schizotypal traits were assayed using a self-report inventory. FTD was indexed using two rating scales; and the dimensional structure of FTD for the sample was identified using PCA. We hypothesized that: 1) the sample would demonstrate elevated schizotypal traits, and elevated FTD assessed using the TLC and TLI; 2) PCA of the TLC and TLI would reveal two- or three-component solutions similar to those reported in patients with schizophrenia; 3) conceptually-related TLC and TLI components would correlate; 4) FTD would associate with psychosis-like experiences in this sample; and 5) FTD would demonstrate a link to general cognitive dysfunction, indexed by IQ scores.

Paper 2 investigates relationships between dimensions of cognitive functioning and FTD in the sample that participated in Paper 1. The approach was informed by recommendations by Berenbaum et al. (2008); and we therefore explored fine-grained distinctions within domains of attention, semantic processing, and executive function that have been reported to be relevant in the clinical FTD literature. FTD dimension scores for the sample were derived in Paper 1. We had one general hypothesis: That significant relationships exist between dimensions of cognitive functioning and FTD in this sample; however, we had no particular expectations about which cognitive dimensions might relate more specifically to particular dimensions of FTD.

This research program was undertaken to contribute to knowledge regarding the underlying dimensional structure of FTD, to identifying the possible cognitive underpinnings of FTD; and to develop cognitive models on which psychological interventions can be based.

Understanding the aetiology of FTD may also assist to identify factors related to progression to psychosis. Findings may also inform the suitability of the continuum approach to FTD research.

References

Alvarez, J. A., & Emory, E. (2006). Executive function and the frontal lobes: A meta-analytic review. *Neuropsychology Review, 16*(1), 17-42. doi: 10.1007/s11065-006-9002-x

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (5th ed.)*. Washington, DC: American Psychiatric Association.

Andreasen, N. (1978). *The Scale for the Assessment of Thought, Language and Communication (TLC)*. Iowa City: The University of Iowa.

Andreasen, N. (1979). Thought, language and communication disorders: II. Diagnostic significance. *Archives of General Psychiatry, 36*(12), 1325-1330. doi: 10.1001/archpsyc.1979.01780120055007

Andreasen, N. (1986). *Scale for Assessment of Thought, Language, and Communication (TLC)*. Retrieved from http://psycnet.apa.

Andreasen, N. (1987). *Comprehensive Assessment of Symptoms and History*. Iowa City, IA: University of Iowa.

Andreasen, N., & Grove, W. M. (1986). Thought, language and communication in schizophrenia: Diagnosis and prognosis. *Schizophrenia Bulletin, 12*(3), 348-359. Retrieved from http://psycnet.apa.org

Andreou, C., Bozikas, V. P., Papouliakos, I., Kosmidis, M. H., Garyfallos, G., Kraravatos, A., & Nimatoudis, I. (2008). Factor structure of the Greek translation of the Scale for the Assessment of Thought, Language and Communication. *Australian and New Zealand Journal of Psychiatry, 2008*(42), 636-642. doi: 10.1080/00048670802119721

Barch, D. M., & Berenbaum, H. (1996). Language production and thought disorder in schizophrenia. *Journal of Abnormal Psychology, 105*(1), 592-601. doi: 10.1037/0021-843X.105.1.81

Barch, D. M., & Berenbaum, H. (1997). The effect of language production manipulations on negative thought disorder and discourse coherence disturbances in schizophrenia. *Psychiatry Research, 71*(2), 115-127. doi: 10.1016/S0165-1781(97)00045-0

Bazin, N., Lefrere, F., Passerieux, C., Sarfati, Y., & Hardy-Bayle, M. C. (2002). Formal thought disorders: French translation of the Thought, Language and Communication assessment scale. *Encephale, 28*(2), 109-119. Retrieved from http://europepmc.org

Bearden, C. E., Wu, K. N., Caplan, R., & Cannon, T. D. (2011). Thought disorder and communication deviance as predictors of outcome in youth at clinical high risk for psychosis. *Journal of the American Academy of Child and Adolescent Psychiatry, 50*(7), 669-680. doi: 10.1016/j.jaac.2011.03.021

Beauchaine, T. P., Lenzenweger, M. F., & Waller, N. G. (2008). Schizotypy, taxometrics, and disconfirming theories in soft science: Comment on Rawlings, Williams, Haslam, and Claridge. *Personality and Individual Differences, 44*(8), 1652-1662. doi: 10.1016/j.paid.2007.11.015

Bentall, R. P., Claridge, G. S., & Slade, P. (1989). The multidimensional nature of schizotypal traits: A factor analytic study with normal subjects. *British Journal of Clinical Psychology, 28*(4), 363-375. doi: 10.1111/j.2044-8260.1989.tb00840.x

Berenbaum, H., Kerns, J. G., Vernon, L. L., & Gomez, J. J. (2008). Cognitive correlates of schizophrenia signs and symptoms: I. verbal communication disturbances. *Psychiatry Research, 159*(1-2), 147-156. doi: 10.1016/j.psychres.2007.08.016

Berenbaum, H., Oltmanns, T. F., & Gottesman, I. I. (1985). Formal thought disorder in schizophrenics and their twins. *Journal of Abnormal Psychology, 94*(1), 3-16. doi: 10.1037//0021-843X.94.1.3

Binder, J. R., Desai, R. H., Graves, W. W., & Conant, L. L. (2009). Where Is the semantic system? A critical review and meta-analysis of 120 functional neuroimaging studies. *Cerebral Cortex, 19*(12), 2767-2796. doi: 10.1093/cercor/bhp055

Blakey, A. F., Hellewell, J. S. E., & Deakin, J. F. W. (1996). Thought disorder in schizophrenia reflects general cognitive impairment and not focal linguistic dysfunction. *Schizophrenia Research, 18*(2-3), 205. doi: 10.1016/0920-9964(96)85633-7

Blanchard, J. J., Collins, L. M., Aghevli, M., Leung, W. W., & Cohen, A. S. (2011). Social anhedonia and schizotypy in a community sample: The Maryland Longitudinal Study of Schizotypy. *Schizophrenia Bulletin, 37*(3), 587-602. doi: 10.1093/schbul/sbp107

Bowie, C. R., Gupta, M., & Holshausen, K. (2011). Disconnected and underproductive speech in schizophrenia: Unique relationships across multiple indicators of social functioning. *Schizophrenia Research, 131*(1–3), 152-156. doi: http://dx.doi.org/10.1016/j.schres.2011.04.014

Bowie, C. R., & Harvey, P. D. (2008). Communication abnormalities predict functional outcomes in chronic schizophrenia: differential association with social and adaptive functions. *Schizophrenia Research, 103*(1-3), 240-247. doi: 10.1016/j.schres.2008.05.006

Caplan, R., Guthrie, D., Tang, B., Nuechterlein, K. H., & Asarnow, R. F. (2000). Thought disorder in attention-deficit hyperactivity disorder. *Journal of the American Academy of Child and Adolescent Psychiatry, 40*(8), 965-972. doi: 10.1097/00004583-200108000-00019

Caplan, R., Perdue, S., Tanguay, P. E., & Fish, B. (1990). Formal thought disorder in childhood onset schizophrenia and schizotypal personality disorder. *Journal of Child*

Psychology and Psychiatry, 31(7), 1103-1114. doi: 10.1111/j.1469-7610.1990.tb00849.x

Claridge, G. (1985). *Origins of mental illness*. Oxford: Blackwell.

Claridge, G. (1994). Single indicator of risk for schizophrenia: probable fact or likely myth? *Schizophrenia Bulletin, 20*(1), 151-168. doi: 10.1093/schbul/20.1.151

Claridge, G., & Davis, C. (2003). *Personality and Psychological Disorders*. London: Arnold.

Coleman, M. J., Levy, D. L., Lenzenweger, M. F., & Holzman, P. S. (1996). Thought disorder, perceptual aberrations, and schizotypy. *Journal of Abnormal Psychology, 105*(3), 469-473. doi: 10.1037/0021-843X.105.3.469

Collins, A. M., & Loftus, E. (1975). A spreading activation theory of semantic processing. *Psychological Review, 82*(6), 407-428. doi: 10.1037/0033-295X.82.6.407

Cuesta, M. J., & Peralta, V. (1999). Thought disorder in schizophrenia. Testing models through confirmatory factor analysis. *European Archives of Psychiatry and Clinical Neuroscience, 249*(2), 55-61. doi: 10.1007/s004060050066

Cuesta, M. J., & Peralta, V. (2011). Testing the hypothesis that formal thought disorders are severe mood disorders. *Schizophrenia Bulletin, 37*(6), 1136-1146. doi: 10.1093/schbul/sbr092

Demjaha, A., Valmaggia, L., Stahl, D., Byrne, M., & McGuire, P. (2012). Disorganization/cognitive and negative symptom dimensions in the at-risk mental state predict subsequent transition to psychosis. *Schizophrenia Bulletin, 38*(2), 351-359. doi: 10.1093/schbul/sbq088

DeVylder, J. E., Muchomba, F. M., Gill, K. E., Ben-David, S., Walder, D. J., Malaspina, D., & Corcoran, C. M. (2014). Symptom trajectories and psychosis onset in a clinical high-risk cohort: The relevance of subthreshold thought disorder. *Schizophrenia Research, 159*(2), 278-283. doi: 10.1016/j.schres.2014.08.008

DeVylder, J. E., Muchomba, F. M., Gill, K. E., Ben-Davida, S., Walder, D. J., Malaspina, D., & Corcoran, C. M. (2014). Symptom trajectories and psychosis onset in a clinical high-risk cohort: The relevance of subthreshold thought disorder. *Schizophrenia Research, 159*(2-3), 278-283. doi: 10.1016/j.schres.2014.08.008

Dickey, C. C., McCarley, R. W., Voglmaier, M. M., Niznikiewicz, M. A., Seidman, L. J., Demeo, S., . . . Shenton, M. E. (2003). An MRI study of superior temporal gyrus volume in women with schizotypal personality disorder. *American Journal of Psychiatry, 160*(12), 2198-2201. doi: 10.1176/appi.ajp.160.12.2198

Docherty, N. M., DeRosa, M., & Andreasen, N. (1996). Communication disturbances in schizophrenia and mania. *Archives of General Psychiatry, 53*(4), 358-364. doi: 10.1001/archpsyc.1996.01830040094014

Docherty, N. M., & Gordinier, S. W. (1999). Immediate memory, attention and communication disturbances in schizophrenia patients and their relatives. *Psychological Medicine, 29*(1), 189-197. doi: 10.1017/S0033291798007843

Docherty, N. M., Gordinier, S. W., Hall, M. J., & Cutting, L. P. (1999). Communication disturbances in relatives beyond the age of risk for schizophrenia and their associations with symptoms in patients. *Schizophrenia Bulletin, 25*(4), 851-862. Retrieved from http://schizophreniabulletin.oxfordjournals.org

Docherty, N. M., McCleery, A., Divilbiss, M., Schumann, E. B., Moe, A., & Shakeel, M. K. (2013). Effects of social cognitive impairment on speech disorder in schizophrenia. *Schizophrenia Bulletin, 39*(3), 608-616. doi: 10.1093/schbul/sbs039

Endicott, J., Spitzer, R. L., Fleiss, J. L., & Cohen, J. (1976). The global assessment scale: A procedure for measuring overall severity of psychiatric disturbance. *Archives of General Psychiatry, 33*(6), 766-771. doi: 10.1001/archpsyc.1976.01770060086012

Fusar-Poli, P. (2012). Voxel-wise meta-analysis of fMRI studies in patients at clinical high risk for psychosis. *Journal of Psychiatry and Neuroscience, 37*(2), 106-112. doi: doi:10.1503/jpn.110021

Gaag, R. J., Caplan, R., Engeland, H., Loman, F., & Buitelaar, J. K. (2005). A controlled study of formal thought disorder in children with autism and multiple complex developmental disorders. *Journal of Child and Adolescent Psychopharmacology, 15*(3), 465-476. doi: 10.1089/cap.2005.15.465

Gagnepain, P., Chételat, G., Landeau, B., Dayan, J., Eustache, F., & Lebreton, K. (2008). Spoken word memory traces within the human auditory cortex revealed by repetition priming and functional magnetic resonance imaging. *The Journal of Neuroscience, 28*(20), 5281-5289. doi: 10.1523/JNEUROSCI.0565-08.2008

Gilbert, C. D. (2015). *Formal Thought Disorder and Functional Outcome in a Community Sample of Patients with Schizophrenia Spectrum Psychosis.* (Doctoral dissertation, Alliant International University). Retrieved from http://gradworks.umi.com

Goldberg, T. E., Aloia, M. S., Gourovitch, M. L., Missar, D., Pickar, D., & Weinberger, D. R. (1998). Cognitive substrates of thought disorder. I: the semantic system. *American Journal of Psychiatry, 155*(12), 1671-1676. doi: 10.1176/ajp.155.12.1671

Goldstein, R. Z., Giovannetti, T., Schullery, M., Zuffante, P. A., Lieberman, J. A., Robinson, D. G., . . . Bilder, R. M. (2002). Neurocognitive correlates of response to treatment in formal thought disorder in patients with first-episode schizophrenia. *Neuropsychiatry, Neuropsychology, and Behavioral Neurology, 15*(2), 88-98. doi: 10.1097/01.WNN.0000012909.43568.91

Gooding, D. C., Coleman, M., Roberts, S. A., Shenton, M. E., Levy, D. L., & Erlenmeyer-Kimling, L. (2010). Thought disorder in offspring of schizophrenic parents: findings

from the New York High-Risk Project. *Schizophrenia Bulletin, 38*(2), 263-271. doi: 10.1093/schbul/sbq061

Gooding, D. C., Ott, S. L., Roberts, S. A., & Erlenmeyer-Kimling, L. (2013). Thought disorder in mid-childhood as a predictor of adulthood diagnostic outcome: findings from the New York High-Risk Project. *Psychological Medicine, 43*(05), 1003-1012. doi: 10.1017/S0033291712001791

Gooding, D. C., Tallent, K. A., & Hegyi, J. V. (2001). Cognitive slippage in schizotypic individuals. *The Journal of Nervous and Mental Disease, 189*(11), 750-756. doi: 10.1097/00005053-200111000-00004

Grube, B. S., Bilder, R. M., & Goldman, R. S. (1998). Meta-analysis of symptom factors in schizophrenia. *Schizophrenia Research, 31*(2–3), 113-120. doi: 10.1016/S0920-9964(98)00011-5

Hafner, H., Maurer, K., Loffler, W., Fatkenheuer, B., Derheiden, W. A., Riecherrossler, A., . . . Gattaz, W. F. (1994). The epidemiology of early schizophrenia - influence of age and gender on onset and early course. *British Journal of Psychiatry, 164*(S23), 29-38. Retrieved from http://psycnet.apa.org

Harrow, M., Grossman, L. S., Silverstein, M. L., & Meltzer, H. Y. (1982). Thought pathology in manic and schizophrenic patients: Its occurrence at hospital admission and seven weeks later. *Archives of General Psychiatry, 39*(6), 665-671. doi: 10.1001/archpsyc.1982.04290060027006

Harrow, M., Marengo, J., & McDonald, C. (1986). The early course of schizophrenic thought disorder. *Schizophrenia Bulletin, 12*(2), 208-224. Retrieved from http://psycnet.apa.org

Harrow, M., & Marengo, J. T. (1986). Schizophrenic thought disorder at followup: its persistence and prognostic significance. *Schizophrenia Bulletin, 12*(3), 373-393. Retrieved from http://psycnet.apa.org

Harvey, P. D. (1985). Reality monitoring in mania and schizophrenia: the association of thought disorder and performance. *Journal of Nervous and Mental Disease, 173*(2), 67-73. doi: 10.1097/00005053-198502000-00001

Harvey, P. D., Earle-Boyer, E. A., & Levinson, J. C. (1988). Cognitive deficits and thought disorder: a retest study. *Schizophrenia Bulletin, 14*(1), 57-66. Retrieved from http://europepmc.org

Harvey, P. D., Earle-Boyer, E. A., Wielgus, M. S., & Levinson, J. C. (1986). Encoding, memory, and thought disorder in schizophrenia and mania. *Schizophrenia Bulletin, 12*(2), 252-261. doi: 10.1093/schbul/12.2.252

Harvey, P. D., Lenzenweger, M. F., Keefe, R. S. E., Pogge, D. L., Serper, M. R., & Mohs, R. C. (1992). Empirical assessment of the factorial structure of clinical symptoms in schizophrenic patients: formal thought disorder. *Psychiatry Research, 44*(2), 141-151. doi: 10.1016/0165-1781(92)90048-8

Harvey, P. D., & Pedley, M. (1989). Auditory and visual distractibility in schizophrenia: clinical and medication status correlations. *Schizophrenia Research, 2*(3), 295-300. doi: 10.1016/0920-9964(89)90006-6

Harvey, P. D., & Serper, M. R. (1990). Linguistic and cognitive failures in schizophrenia. A multivariate analysis. *Journal of Nervous and Mental Disease, 178*(8), 487-493. doi: 10.1097/00005053-199017880-00003

Heaton, R. K. (1981). *Wisconsin card sorting test manual*. Odessa, Florida: Psychological Assessment Resources.

Heinrichs, R. W., & Zakzanis, K. K. (1998). Neurocognitive deficit in schizophrenia: a quantitative review of the evidence. *Neuropsychology, 12*(3), 426-445. doi: 10.1037//0894-4105.12.3.426

Holzman, P. S., Shenton, M. E., & Solovay, M. R. (1986). Quality of thought disorder in differential diagnosis. *Schizophrenia Bulletin, 12*(3), 360-371. Retrieved from http://psycnet.apa.org

Horan, W. P., Brown, S. A., & Blanchard, J. J. (2007). Social anhedonia and schizotypy: the contribution of individual differences in affective traits, stress, and coping. *Psychiatry Research, 149*(1-3), 147-156. doi: 10.1016/j.psychres.2006.06.002

Horn, H., Federspiel, A., Wirth, M., Müller, T. J., Wiest, R., Walther, S., & Strik, W. (2010). Gray matter volume differences specific to formal thought disorder in schizophrenia. *Psychiatry Research: Neuroimaging, 182*(2), 183-186. doi: 10.1016/j.pscychresns.2010.01.016

Horn, H., Federspiel, A., Wirth, M., Muller, T. J., Wiest, R., Wang, J., & Strik, W. (2009). Structural and metabolic changes in language areas linked to formal thought disorder. *The British Journal of Psychiatry, 194*(2), 130-138. doi: 10.1192/bjp.bp.107.045633

Howard, R., Castle, D., Wessely, S., & Murray, R. (1993). A comparative study of 470 cases of early-onset and late onset schizophrenia. *British Journal of Psychiatry, 163*(3), 352-357. doi: 10.1192/bjp.163.3.352

Johns, L. C., & van Os, J. (2001). The continuity of psychotic experiences in the general population. *Clinical Psychology Review, 21*(8), 1125-1141. doi: 10.1016/S0272-7358(01)00103-9

Johnston, M. H., & Holzman, P. S. (1979). *Assessing schizophrenic thinking: a clinical and research instrument for measuring thought disorder*. San Francisco: Jossey-Bass.

Jones, P. B. (2013). Adult mental health disorders and their age at onset. *The British Journal of Psychiatry, 202*(S54), S5-S10. doi: 10.1192/bjp.bp.112.119164

Kerns, J. G., & Becker, T. M. (2008). Communication disturbances, working memory, and emotion in people with elevated disorganized schizotypy. *Schizophrenia Research, 100*(1-3), 172-180. doi: 10.1016/j.schres.2007.11.005

Kerns, J. G., & Berenbaum, H. (2002). Cognitive impairments associated with formal thought disorder in people with schizophrenia. *Journal of Abnormal Psychology, 111*(2), 211-224. doi: 10.1037/0021-843X.111.2.211

Kessler, R. C., Amminger, G. P., Aguilar-Gaxiola, S., Alonso, J., Lee, S., & Ustun, T. B. (2007). Age of onset of mental disorders: A review of recent literature. *Current Opinion in Psychiatry, 20*(4), 359-364. doi: 10.1097/YCO.0b013e32816ebc8c.

Kiang, M. (2010). Schizotypy and language: A review. *Journal of Neurolinguistics, 23*(3), 193-203. Retrieved from http://www.sciencedirect.com

Kircher, T., Krug, A., Stratmann, M., Ghazi, S., Schales, C., Frauenheim, M., . . . Nagels, A. (2014). A rating scale for the assessment of objective and subjective formal Thought and Language Disorder (TALD). *Schizophrenia Research, 160*(1–3), 216-221. doi: 10.1016/j.schres.2014.10.024

Kircher, T. T., Liddle, P. F., Brammer, M. J., Williams, S. C., Murray, R. M., & Mcguire, P. K. (2002). Reversed lateralization of temporal activation during speech production in thought disordered patients with schizophrenia. *Psychological Medicine, 32*(3), 439-449. doi: 10.1017/S0033291702005287

Köther, U., Veckenstedt, R., Vitzthum, F., Roesch-Ely, D., Pfueller, U., Scheu, F., & Moritz, S. (2012). "Don't give me that look" — Overconfidence in false mental state perception in schizophrenia. *Psychiatry Research, 196*(1), 1-8. doi: 10.1016/j.psychres.2012.03.004

Kraepelin, E. (1919/trans.1999). *Dementia praecox and paraphrenia*. Huntington, NY: Robert E. Kreiger Publishing Co., Inc.

Levine, J., Schild, K., Kimhi, R., & Schreiber, G. (1996). Word associative production in affective versus schizophrenic psychosis. *Psychopathology, 29*(1), 7-13. doi: 10.1159/000284966

Levitt, J. J., Bobrow, L., Lucia, D., & Srinivasan, P. (2010). A selective review of volumetric and morphometric imaging in schizophrenia. *Current Topics in Behavioural Neuroscience, 4*, 243-281. Retrieved from http://www.ncbi.nlm.nih.gov

Levy, D. L., Coleman, M. J., Sung, H., Ji, F., Matthysse, S., Mendell, N. R., & Titone, D. (2010). The genetic basis of thought disorder and language and communication disturbances in schizophrenia. *Journal of Neurolinguistics, 23*(3), 176. doi: doi:10.1016/j.jneuroling.2009.08.003

Liddle, P. F. (1987). The symptoms of chronic schizophrenia. A re-examination of the positive-negative dichotomy. [Journal Article]. *British Journal of Psychiatry, 151*(2), 145-151. doi: 10.1192/bjp.151.2.145

Liddle, P. F. (1995). *Thought, Language, and Communication Index.* University of Vancouver, Vancouver, BC.

Maeda, K., Kasai, K., Uetsuki, M., Hata, A., Araki, T., Rogers, M. A., . . . Iwanami, A. (2007). Increased positive thought disorder with illness duration in patients with schizophrenia. *Psychiatry and Clinical Neurosciences, 61*(6), 687-690. doi: 10.1111/j.1440-1819.2007.01730.x

Makowski, D. , Waternaux, C., Lajonchere, C. M . , Dicker, R., Smoke, N., Koplewicz, H., . . . Levyf, D. L. (1997). Thought disorder in adolescent-onset schizophrenia. *Schizophrenia Research, 23*(2), 147-165. doi: 10.1016/S0920-9964(96)00097-7

Marengo, J., & Harrow, M. (1985). Thought disorder. A function of schizophrenia, mania, or psychosis? *Journal of Nervous and Mental Disease, 173*(1), 35-41. doi: 10.1097/00005053-198501000-00006

McGrath, J. (1991). Ordering thoughts on thought disorder. *British Journal of Psychiatry, 158*, 307-316. doi: 10.1192/bjp.158.3.307

McGrath, J., Scheldt, S., & Hengstberger, P. (1997). Thought disorder and executive ability. *Cognitive Neuropsychiatry, 2*(4), 303-314. doi: 10.1080/135468097396306

McGrath, J., Scheldt, S., Welham, J., & Clair, A. (1997). Performance on tests sensitive to impaired executive ability in schizophrenia, mania and well controls: acute and subacute phases. *Schizophrenia Research, 26*(2-3), 127-137. doi: 10.1016/S0920-9964(97)00070-4

McKenna, P. J., & Oh, T. M. (2005). *Schizophrenic speech: Making sense of bathroots and ponds that fall in doorways*. Cambridge: Cambridge University Press.

Meehl, P. E. (1962). Schizotaxia, schizotypy and schizophrenia. *American Psychologist, 17*(12), 827-838. doi: 10.1037/h0041029

Metsanen, M., Wahlberg, K., Saarento, O., Tarvainen, T., Miettunen, J., Koistinen, P., . . . Tienari, P. (2004). Early presence of thought disorder as a prospective sign of mental disorder. *Psychiatry Research, 125*(3), 193-203. doi: 10.1016/j.psychres.2004.01.002

Minor, K. S., & Cohen, A. S. (2010). Affective reactivity of speech disturbances in schizotypy. *Journal of Psychiatric Research, 44*(2), 99-105. doi: 10.1016/j.jpsychires.2009.06.005

Minor, K. S., Cohen, A. S., Weber, C. R., & Brown, L. A. (2011). The relationship between atypical semantic activation and odd speech in schizotypy across emotionally evocative conditions. *Schizophrenia Research, 126*(1-3), 144-149. doi: 10.1016/j.schres.2010.06.016

Mohr, C., Graves, R. E., Gianotti, L. R., Pizzagalli, D., & Brugger, P. (2001). Loose but normal: a semantic association study. *Journal of Psycholinguistic Research, 30*(5), 475-483. doi: 10.1023/A:1010461429079

Moser, R. Kevin, Cienfuegos, Angel, Barros, Jorge, & Javitt, Daniel. (2001). Auditory distraction and thought disorder in chronic schizophrenic inpatients: evidence for separate contributions by incapacity and poor allocation and a subsyndrome related to the allocation deficit. [doi: DOI: 10.1016/S0920-9964(00)00122-5]. *Schizophrenia Research, 51*(2-3), 163-170.

Musalek, M., Larach-Walters, V., Lepine, J. P., Millet, B., & Gaebel, W. (2010). Psychopathology in the 21st century. *World Journal of Biological Psychiatry, 11*(7), 844-851. doi: 10.3109/15622975.2010.510207

Nagels, A., Stratmann, M., Ghazi, S., Schales, C., Frauenheim, M., Turner, L., . . . Kircher, T. T. (2013). The German translation and validation of the Scale for the Assessment of Thought, Language and Communication: A factor analytic study. *Psychopathology, 46*(6), 390-395. doi: 10.1159/000345359

Nelson, M. T., Seal, M. L., Pantelis, C., & Phillips, L. J. (2013). Evidence of a dimensional relationship between schizotypy and schizophrenia: A systematic review. *Neuroscience and Biobehavioral Reviews, 37*, 317-327. doi: 10.1016/j.neubiorev.2013.01.004

Neuvo, R., Chatterji, S., Verdes, E., Naidoo, N., Arango, C., & Ayuso-Mateos, J. L. (2012). The continuum of psychotic symptoms in the general population: a cross-national study. *Schizophrenia Bulletin, 38*(3), 475-485. doi: 10.1093/schbul/sbq099

Ott, S. L., Roberts, S., Rock, D., Allen, J., & Erlenmeyer-Kimling, L. (2002). Positive and negative thought disorder and psychopathology in childhood among subjects with

adulthood schizophrenia. *Schizophrenia Research, 58*(2-3), 231-239. doi: 10.1016/S0920-9964(01)00339-5

Pandurangi, A. K., Sax, K. W., Pelonero, A. L., & Goldberg, S. C. (1994). Sustained attention and positive formal thought disorder in schizophrenia. *Schizophrenia Research, 13*(2), 109-116. doi: 10.1016/0920-9964(94)90091-4

Park, S., & Gooding, D. C. (2014). Working memory impairment as an endophenotypic marker of a schizophrenia diathesis. *Schizophrenia Research: Cognition, 1*(3), 127-136. doi: 10.1016/j.scog.2014.09.005

Patterson, K., Nestor, P. J., & Rogers, T. T. (2007). Where do you know what you know? The representation of semantic knowledge in the human brain. *Nature Reviews Neuroscience, 8*(12), 976-987. doi: 10.1038/nrn2277

Peralta, V., Cuesta, M. J., & De Leon, J. (1992). Formal thought disorder in schizophrenia: a factor analytic study. *Comprehensive Psychiatry, 33*(2), 105-110. doi: 10.1016/0010-440X(92)90005-B

Persons, J. B. (1986). The advantages of studying psychological phenomena rather than psychiatric diagnoses. *American Psychologist, 41*(11), 1252-1260. doi: 10.1037/0003-066X.41.11.1252

Racenstein, J., Meg, M. A., Penn, D., Harrow, M., & Schleser, R. (1999). Thought disorder and psychosocial functioning in schizophrenia: the concurrent and predictive relationships. *Journal of Nervous and Mental Disease, 187*(5), 281-289. doi: 10.1097/00005053-199905000-00003

Rajarethinam, R. P., DeQuardo, J. R., Nalepa, R., & Tandon, R. (2000). Superior temporal gyrus in schizophrenia: a volumetric magnetic resonance imaging study. *Schizophrenia Research, 41*(2), 303-312. doi: 10.1016/S0920-9964(99)00083-3

Rawlings, D., Williams, B., Haslam, N., & Claridge, G. (2008). Taxometric analysis supports a dimensional latent structure for schizotypy. *Personality and Individual Differences, 44*(8), 1640-1651. doi: 10.1016/j.paid.2007.06.005

Reilly, R., Harrow, M., Tucker, G. J., Quinlan, D., & Siegel, A. (1975). Looseness of associations in acute schizophrenia. *British Journal of Psychiatry, 127*, 240-246. doi: 10.1192/bjp.127.3.240

Roche, E., Creed, L., MacMahon, D., Brennan, D., & Clarke, M. (2014). The epidemiology and associated phenomenology of formal thought disorder: A systematic review. *Schizophrenia Bulletin*. doi: Advance online publication. doi: 10.1093/schbul/sbu129

Rochester, S. R. (1978). Are language disorders in acute schizophrenia actually information processing problems? [10.1016/0022-3956(78)90030-4]. *Journal of Psychiatric Research, 14*(1-4), 275-283.

Rodriguez-Ferrera, S., McCarthy, R. A., & McKenna, P. J. (2001). Language in schizophrenia and its relationship to formal thought disorder. *Psychological Medicine, 31*(2), 197-205. doi: 10.1017/S003329170100321X

Roisko, R., Wahlberg, K. E., Hakko, H., & Tienari, P. (in-press). Association of adoptive child's thought disorders and schizophrenia spectrum disorders with their genetic liability for schizophrenia spectrum disorders, season of birth and parental communication deviance. *Psychiatry Research*. doi: 10.1016/j.psychres.2014.12.036

Roisko, R., Wahlberg, K. E., Miettunen, J., & Tienari, P. (2014). Association of parental communication deviance with offspring's psychiatric and thought disorders. A systematic review and meta-analysis. *European Psychiatry, 29*(1), 20-31. doi: 10.1016/j.eurpsy.2013.05.002

Ruhrmann, S., Schultze-Lutter, F., Salokangas, R. R., & et al. (2010). Prediction of psychosis in adolescents and young adults at high risk: Results from the prospective european

prediction of psychosis study. *Archives of General Psychiatry, 67*(3), 241-251. doi: 10.1001/archgenpsychiatry.2009.206

Rumsey, J. M., Andreasen, N. C., & Rapoport, J. L. (1986). Thought, language, communication, and affective flattening in autistic adults. *Archives of General Psychiatry, 43*(8), 771-777. doi: 10.1001/archpsyc.1986.01800080057008.

Sans-Sansa, B., McKenna, P. J., Canales-Rodriguez, E. J., Ortiz-Gil, J., Lopez-Araquistain, L. L., Sarro, S., . . . Pomarol-Clotet, E. (2013). Association of formal thought disorder in schizophrenia with structural brain abnormalities in language-related cortical regions. *Schizophrenia Research, 146*(1-3), 308-313. doi: 10.1016/j.schres.2013.02.032

Seidman, L. J., Hellemann, G., Nuechterlein, K. H., Greenwood, T. A., Braff, D. L., Cadenhead, K. S., . . . Green, M. F. (2015). Factor structure and heritability of endophenotypes in schizophrenia: Findings from the Consortium on the Genetics of Schizophrenia (COGS-1). *Schizophrenia Research, 163*(1-3), 73-79. doi: 10.1016/j.schres.2015.01.027

Shenton, M. E., Kikinis, R., Jolesz, F. A., Pollak, S. D., LeMay, M., Wible, C. G., . . . Coleman, M. (1992). Abnormalities of the left temporal lobe and thought disorder in schizophrenia. A quantitative magnetic resonance imaging study. *New England Journal of Medicine, 327*(9), 604-612. doi: 10.1056/NEJM199208273270905

Shenton, M. E., Solovay, M. R., & Holzman, P. S. (1987). Comparative studies of thought disorders. II. Schizoaffective disorder. *Archives of General Psychiatry, 44*(1), 21-30. doi: 10.1001/archpsyc.1987.01800130023004

Siever, L. J., & Davis, K. L. (2004). The pathophysiology of schizophrenia disorders: perspectives from the spectrum. *American Journal of Psychiatry, 161*(3), 398-413. doi: 10.1176/appi.ajp.161.3.398

Smith, D. A., Mar, C. M., & Turoff, B. K. (1998). The structure of schizophrenic symptoms: a meta-analytic confirmatory factor analysis. *Schizophrenia Research, 31*(1), 57-70. doi: 10.1016/S0920-9964(98)00009-7

Smith, T., Hull, J., Goodman, M., Hedayat-Harris, A., Wilson, D., Israel, L., & Munich, R. (1999). The relative influences of symptoms, insight, and neurocognition on social adjustment in schizophrenia and schizoaffective disorder. *Journal of Nervous and Mental Disease, 187*(2), 102-108. doi: 10.1097/00005053-199902000-00006

Solovay, M. R., Shenton, M. E., Gasperetti, C., Coleman, M., Kestnbaum, E., Carpenter, J. T., & Holzman, P. S. (1986). Scoring manual for the thought disorder index (revised version). *Schizophrenia Bulletin, 12*(3), 483-496. Retrieved from http://europepmc.org

Solovay, M. R., Shenton, M. E., & Holzman, P. S. (1987). Comparative studies of thought disorders. I. Mania and schizophrenia. *Archives of General Psychiatry, 44*(1), 13-20. doi: 10.1001/archpsyc.1987.01800130015003

Sommer, I. E., Derwort, A. M. C., Daalman, K., de Weijer, A. D., Liddle, P. F., & Boks, M. P. M. (2010). Formal thought disorder in non-clinical individuals with auditory verbal hallucinations. *Schizophrenia Research, 118*(1-3), 140-145. doi: 10.1016/j.schres.2010.01.024

Sommer, R., Dewar, R., Osmond, H., & Sask, W. (1960). Is there a schizophrenic language? *Archives of General Psychiatry, 3*(6), 665-673. doi: 10.1001/archpsyc.1960.01710060097014

Squire, L. R. (2004). Memory systems of the brain: a brief history and current perspective. *Neurobiol Learn Mem, 82*(3), 171-177. doi: 10.1016/j.nlm.2004.06.005

Stirling, J., Hellewell, J., Blakeley, A., & Deakin, W. (2006). Thought disorder in schizophrenia is associated with both executive dysfunction and circumscribed

impairments in semantic function. *Psychological Medicine, 36*(4), 475-484. doi: 10.1017/S0033291705006884

Stone, W. S., & Hsi, X. (2011). Recent developments in neuropsychological endophenotypes for schizophrenia: Development of the MATRICS battery, liability syndromes and the near future. *Chinese Science Bulletin, 56*(32), 3385-3393. doi: 10.1007/s11434-011-4759-6

Subotnik, K. L., Bartzokis, G., Green, M. F., & Nuechterlein, K. H. (2003). Neuroanatomical correlates of formal thought disorder in schizophrenia. *Cognitive Neuropsychiatry, 8*(2), 81-88. doi: 10.1080/13546800244000148

Tabachnick, B. G., & Fidell, L. S. (2001). *Using multivariate statistics* (Fourth ed.). Needham Heights, MA: A Pearson Education Company.

Takahashi, T., Wood, S. J., Yung, A. R., Soulsby, B., McGorry, P. D., Suzuki, M., . . . Pantelis, C. (2009). Progressive gray matter reduction of the superior temporal gyrus during transition to psychosis. *Archives of General Psychiatry, 66*(4), 366-376. doi: doi: 10.1001/archgenpsychiatry.2009.12.

Tan, E. J., Thomas, N., & Rossell, S. L. (2014). Speech disturbances and quality of life in schizophrenia: differential impacts on functioning and life satisfaction. *Comprehensive Psychiatry, 55*(3), 693-698. doi: 10.1016/j.comppsych.2013.10.016

Taylor, M. A., Reed, R., & Berenbaum, S. (1994). Patterns of speech disorders in schizophrenia and mania. *Journal of Nervous and Mental Disease, 182*(6), 319-326. doi: 10.1097/00005053-199406000-00002

Uhlhaas, P. J., Silverstein, S. M., Phillips, W. A., & Lovell, P. G. (2004). Evidence for impaired visual context processing in schizotypy with thought disorder. *Schizophrenia Research, 68*(2-3), 249-260. doi: 10.1016/S0920-9964(03)00184-1

van Os, J., Linscott, R. J., Myin-Germeys, L., Delespaul, P., & Krabbendam, L. (2009). A systematic review and meta-analysis of the psychosis continuum: evidence for a psychosis proneness-persistence-impairment model of psychotic disorder. *Psychological Medicine, 39*(2), 179-195. doi: 10.1017/S0033291708003814

Walker, E., & Harvey, P. D. (1986). Positive and negative symptoms in schizophrenia: attentional performance correlates. *Psychopathology, 19*(6), 294-302. doi: 10.1159/000284452

Weinstein, S., McKay, R., & Ngan, E. T. (2008). Positive schizotypy is not associated with speech abnormality. *Early Intervention in Psychiatry, 2*(2), 98-102. doi: 10.1111/j.1751-7893.2008.00064.x

Wilcox, J., Briones, D., Quadri, S., & Tsuang, M. (2014). Prognostic implications of paranoia and thought disorder in new onset psychosis. *Comprehensive Psychiatry, 55*(4), 813-817. doi: 10.1016/j.comppsych.2013.12.010

Wilcox, J., Winokur, G., & Tsuang, M. (2012). Predictive value of thought disorder in new-onset psychosis. *Comprehensive Psychiatry, 53*(6), 674-678. doi: 10.1016/j.comppsych.2011.12.002

Yeo, R. A., Gangestad, S. W., Walton, E., Ehrlich, S., Pommy, J., Turner, J. A., . . . Calhoun, V. D. (2014). Genetic influences on cognitive endophenotypes in schizophrenia. *Schizophrenia Research, 156*(1), 71-75. doi: 10.1016/j.schres.2014.03.022

Paper One

"Formal Thought Disorder" in Homeless Young Adults with Elevated Schizotypal Traits: Underlying Dimensional Structure

Candidate's contribution: The candidate has played a major role in organising the protocols and setting up the paradigms for this paper. In addition, the candidate has collected all data, conducted all initial analyses, and has acted as senior author.

Abstract

Background and Aims: Different dimensions of formal thought disorder (FTD) have been distinguished by different patterns of cognitive dysfunction and variability in cortical structure in patients with schizophrenia; however, inconsistency in findings may relate to patient-related confounds. An important research stream uses non-patient samples with elevated schizotypal traits, as these are free of confounds relating to antipsychotic medications and institutionalisation. However, the utility of this approach to FTD research is unknown.

Method: We performed principal components analysis (PCA) of FTD ratings using the Scale for the Assessment of Thought, Language and Communication (TLC) and the Thought and Language Index (TLI) in a general-community sample (N = 92 and 89, respectively) of homeless young adults. Recruitment was from youth homeless services, as homeless adults who are otherwise free of psychotic illness have been shown to have elevated schizotypal traits.

Results: As expected, the sample showed elevated schizotypal traits, as indexed by the Schizotypal Personality Questionnaire (SPQ). Borderline traits indexed by the Borderline Personality Questionnaire (BPQ) were also high. Both the TLC and TLI showed "clinically-elevated" communicative disturbances, more so for the TLC. PCA described a three-component TLC solution ("Disorganisation", "Verbosity", "Emptiness") and two-component TLI solution ("Negative", "Idiosyncratic"), generally consistent with schizophrenia research. Correlations between TLC and TLI dimensions were low however, likely reflecting differences in how the speech samples are elicited for each scale. TLC "Disorganization" and "Emptiness" ratings, but not the TLI ratings, correlated with psychosis-like experiences indexed by the SPQ and BPQ. In contrast, TLI "Negative" scores associated most strongly with lower IQ.

Conclusion: Findings suggest that the TLC may be more useful with regard to revealing a finer-grained dimensional structure of FTD that associates with psychosis-like experiences in general-community samples.

Keywords: formal thought disorder, schizophrenia, schizotypy, Scale for the Assessment of Thought, Language and Communication, Thought and Language Index

"Formal Thought Disorder" in Homeless Young Adults with Elevated Schizotypal Traits: Underlying Dimensional Structure

Disturbances of speech are characteristic of schizophrenia (American Psychiatric Association, 2013); and are typically referred to as *formal thought disorder* (FTD). The term originates from traditional psychiatry, which sought to distinguish abnormality of *content* of thought (e.g., delusions) from peculiarity of the *form* of thought, as revealed through speech (e.g., changing the topic of conversation disjointedly). The usual approach to indexing FTD is by rating scales of interviews or other speech samples, of which the Scale for the Assessment of Thought, Language and Communication (TLC, Andreasen, 1978) is the most prominent (for discussion, see McKenna & Oh, 2005). Although usually considered in relation to schizophrenia, FTD has also been described in mania, schizoaffective disorder, and other clinical conditions (for discussion, see McKenna & Oh). Objectively-rated FTD may also be evident in persons without psychotic illness, including normal controls (Andreasen & Grove, 1986), undergraduates with attenuated schizophrenia-like traits (i.e., schizotypal traits, Coleman, Levy, Lenzenweger, & Holzman, 1996), and clinically-unaffected biological relatives of individuals with schizophrenia (Docherty & Gordinier, 1999; Gooding et al., 2010; Ott, Roberts, Rock, Allen, & Erlenmeyer-Kimling, 2002). Thus, as FTD has been observed in various patient groups and persons without psychiatric illness, it has been proposed that FTD may be a continuum phenomenon also expressed in the normal population (Andreasen, 1979b). Related to this latter point, longitudinal research has shown that FTD may be elevated in childhood many years prior to schizophrenia onset among the offspring of patients with schizophrenia (Gooding, Ott, Roberts, & Erlenmeyer-Kimling, 2013; Ott, et al.). Also relevant here is that FTD is among the most predictive of the signs and symptoms for

transition to psychosis in high-risk cohorts (Bearden, Wu, Caplan, & Cannon, 2011; Demjaha, Valmaggia, Stahl, Byrne, & McGuire, 2012; DeVylder et al., 2014).

FTD is usually regarded as having both positive and negative features. *Positive FTD* (PFTD) typically refers to the presence of abnormalities in the form of speech, such as responding obliquely or speech that is incoherent. It is often seen in patients with acute schizophrenia or mania; and associated with intact or excessive affect (Andreasen, 1979b). In contrast, *negative FTD* (NFTD) usually consists of vague empty speech or poverty of amount of speech; and occurs most often in chronic schizophrenia, where flat affect and apathy predominate (Andreasen). The relative independence of PFTD and NFTD in schizophrenia is supported by clinical and experimental findings (for review, see Cuesta & Peralta, 1999). Experimentally, PFTD and NFTD have been distinguished by different patterns of cognitive dysfunction in patients with schizophrenia (Harvey, Earle-Boyer, & Levinson, 1988). For example, Harvey and Serper (1990) found that greater PFTD (TLC *pressure of speech, derailment,* and *tangentiality*) was associated with poorer performance on tests indexing span of attention, freedom from distractibility, and source monitoring in their sample of inpatients with schizophrenia (n = 38), while NFTD (TLC *poverty of speech* and *poverty of content of speech*) was unrelated to these measures. Also experimentally, different patterns of cortical volume loss have been described in PFTD and NFTD. Among this evidence, Sans-Sansa et al. (2013) found that PFTD (TLC *tangentiality, derailment, loss of goal, illogicality, circumstantiality,* and *incoherence*) was associated with grey-matter reduction within the left superior temporal cortex and left frontal inferior operculum/pars triangularis, regions associated with language functioning, in their sample of right-handed patients with chronic schizophrenia, suggesting that PFTD relates more to a breakdown of basic language processes: Whereas, NFTD (TLC *poverty of content of speech*) was related to volume

reduction of the ventromedial frontal and orbitofrontal cortex bilaterally, regions associated with higher-order executive functions that may contribute to "speech output and content".

However, many studies suggest that the dimensional structure of FTD may be more nuanced than a simple positive-negative dichotomy. Research investigating the underlying structure of FTD using variable reduction techniques, such as principal components analysis (PCA), describes three generally reliable dimensions using the TLC, usually labelled as Disorganisation, Emptiness/Negative, and either Verbosity or Linguistic Control (Andreasen, 1979b; Andreasen & Grove, 1986; Andreou et al., 2008; Bazin, Lefrere, Passerieux, Sarfati, & Hardy-Bayle, 2002; Berenbaum, Oltmanns, & Gottesman, 1985; Cuesta & Peralta, 1999, 2011; Harvey et al., 1992; Nagels et al., 2013; Ott, et al., 2002; Peralta, Cuesta, & De Leon, 1992; Taylor, Reed, & Berenbaum, 1994). However, findings have been mixed. For example, Harvey et al. (1992) found support for Berenbaum, Oltmanns, and Gottesman's two-factor model comprising Verbal Productivity and Disconnection, while Cuesta and Peralta (1999) reported a best-fitting six-dimensional solution (Disorganization, Negative, Idiosyncratic, Semantic, Attentional, and Referential).

These inconsistencies may reflect differences across clinical samples and possible confounding effects associated with stage of illness or medication, for example. A contemporary dimensional perspective that may circumvent any such confounds regards schizophrenia as the extreme end-point of a psychosis continuum that also manifests in schizotypal traits at the sub-clinical end (for discussion, see van Os, Linscott, Myin-Germeys, Delespaul, & Krabbendam, 2009). Empirical support for the *continuum model* has recently been reviewed (Ettinger, Meyhöfer, Steffens, Wagner, & Koutsouleris, 2014; Nelson, Seal, Pantelis, & Phillips, 2013); and includes multidisciplinary evidence of neurobiological, cognitive, psychopharmacological, genetic, perceptual, social, environmental, symptom

structure, and motor similarities between clinical schizophrenia and non-clinical schizotypy, commonly indexed using self-report questionnaires, such as the Schizotypal Personality Questionnaire (SPQ; Raine, 1991).

The potential usefulness of the continuum approach to FTD research is consistent with evidence linking psychometrically-elevated schizotypal traits with objectively-rated communication disturbances in undergraduate samples (Coleman, et al., 1996; Minor & Cohen, 2010), as schizotypal traits are conceived as part of the schizophrenia continuum. As well, preliminary evidence indicates a possible relationship between communication disturbances and working memory dysfunction in individuals with elevated schizotypal traits, which would be consistent with meta-analysis linking working memory dysfunction and FTD in samples with schizophrenia (Kerns & Berenbaum, 2002): Kerns and Becker (2008) found that more unclear meanings for negative speech topics rated using the Communication Disturbance Index (Docherty, 1996) was related to poorer working-memory test performance in undergraduates with elevated disorganized schizotypal traits using the Cognitive Slippage Scale (Miers & Raulin, 1987). Further, neuroimaging research reports similar patterns of reduced volume to brain structures associated with semantic memory functioning in persons diagnosed with schizotypal personality disorder (SPD) and individuals with schizophrenia (for review, see Fervaha & Remington, 2013). This is relevant to understanding FTD, as considerable evidence also relates semantic memory dysfunction with FTD in patients with schizophrenia (Kerns & Berenbaum, 2002).

However, it must be acknowledged that not all studies report an association between schizotypal traits and objectively-rated communication disturbance (Weinstein, McKay, & Ngan, 2008). This inconsistency may reflect limited variability of FTD in highly-educated university samples. Further to this concern, Peterson (2001) performed a second-order meta-

analysis of Social Psychology research (*N* subjects > 1,000,000), and found that student samples were consistently less variable on constructs of interest, a factor that may obscure or reduce the size of actual relationships between variables. More broadly, Peterson also reported that about 20% of conclusions based on students differed directionally from non-student comparisons; and 29% of the relationships differed in magnitude by a factor of two or more. An alternative and relatively convenient recruitment strategy for applying the continuum approach to FTD research is suggested by evidence indicating a high prevalence of SPD among homeless adults who are otherwise free of psychotic illness (38%, Connolly, Cobb-Richardson, & Ball, 2008). For example, recruitment from accommodation and other support services may provide a relatively efficient recruitment strategy for continuum studies of FTD. Such a sample may also be more representative of the psychosocial adversity and disadvantage that have been associated with schizotypal traits in the general-community (Velikonja, Fisher, Mason, & Johnson, 2015).

Another consideration with regard to the potential usefulness of the continuum approach for FTD research relates to the scale that is used to index FTD. The majority of clinical FTD studies have used the TLC. The strengths of the TLC include that it provides clear descriptions, exemplars, and a scoring system for 18 FTD subtypes according to observed frequency or intensity during a semi-structured clinical interview, as well as Total and Global summary scores. However, to increase variance for analysis in a sample without psychotic illness, one may also need to measure the variable of interest (FTD in this case) with a more sensitive index or use different scales. FTD scales vary in approach used to operationalize ratings of FTD and with how the speech sample is collected and rated (e.g., interview versus speech samples to describe pictures), as occurs for the Thought and Language Index (TLI, Liddle et al., 2002). In more detail, the TLI was developed to index subtle aberrations of

speech. To derive the TLI speech sample, participants are asked to describe eight images, such as from the Thematic Apperception Test (TAT, Murray, 1943). The descriptions and replies to questions are rated for eight items that correspond to a subset of conceptually-related TLC items. However, usage of different scales (e.g., TLC versus TLI) may limit comparison of findings across previous studies. For example, it seems plausible that the everyday task of describing pictures might assist to keep a person's speech "on track", whereas there may be a tendency during an interview to reply tangentially due to misunderstanding questions, or to eventually derail off-topic due to limited ability to retain the topic of conversation in mind. In the context of applying the continuum approach to FTD research, demonstrating comparable FTD-research findings between samples of patients with schizophrenia and non-clinical community-based persons with psychometrically-elevated schizotypal traits is critical to establishing the validity of the continuum approach to FTD research. Most schizophrenia-related FTD research has used the TLC; however, no study has used the TLC to investigate FTD in a non-clinical general-community (as opposed to university) sample of persons with psychometrically-identified schizotypal traits. Thus, the sensitivity of the TLC to detect FTD in this group is unknown and inclusion of an additional rating scale, the TLI, which putatively provides a more sensitive index of FTD, is warranted.

Aims and Hypotheses

To date, no study has examined the underlying dimensional structure of FTD in a general-community sample with psychometrically-elevated schizotypal traits. The primary aim of this study was therefore to examine levels of FTD, in particular, the dimensional structure of FTD, in a general-community sample of young adults attending services for homeless youth with elevated schizotypal traits using both the TLC and TLI. Thus, we performed PCA on ratings of speech samples collected using the TLC and TLI. We used both

of these FTD rating tools, as this permitted comparison across these approaches in this sample. Using the TLC also facilitated comparison with findings from clinical FTD research in samples with schizophrenia. As a secondary aim, we also sought to determine whether FTD in this sample related to psychosis-like experiences, mood, substance use, education, sex, or other demographic variable.

We hypothesized: 1) the sample would demonstrate elevated schizotypal traits and FTD assessed using the TLC and TLI; 2) PCA of the TLC and TLI would reveal two- or three-component solutions similar to those reported in patients with schizophrenia; 3) conceptually-related TLC and TLI components would correlate; 4) FTD would be associated with psychosis-like experiences in this sample; and 5) FTD would demonstrate a link to general cognitive dysfunction, indexed by IQ scores.

Method

Sample and Participant Selection

A total of 126 potential participants were recruited at two large youth welfare services located in Sydney and Melbourne, Australia. Eligibility criteria included: age range 16-25 years, English as first language, and self-reported alcohol and drug abstinence for the previous 24 hours. Exclusion criteria included: low verbal or low performance IQ (due to task demands); inadequate effort on task assessment (see later for details); or diagnosis of Diagnostic and Statistical Manual (DSM) of Mental Disorders-V Axis I psychotic illness, central nervous system disease, developmental disorder, or history of head injury with loss of consciousness exceeding one hour. Twenty-one were thus excluded: three reported diagnosis of schizophrenia, three bi-polar disorder, and one intellectual disability; eight spoke English as a second language; three had histories of severe head injury and one reported a previous stroke; one had low IQ; and one had difficulty complying with test protocols. Another 13

eligible participants did not complete the testing session. Data is therefore reported for a final sample of 92 participants. Participants were reimbursed $60 in the form of gift cards. They were provided written informed consent and treated in accordance with the Australian Psychological Society's *Code of Ethics* (Australian Psychological Society, 2003). Macquarie University's Human Research Ethics Committee approved the study (5201001263).

Materials

Cognitive screening measures.

Inadequate effort*:* The *Test of Memory Malingering* (ToMM, Tombaugh, 1996) was used to screen for adequate test-taking effort as recommended in neuropsychological research (Larrabee, 2012; Rohling & Boone, 2007): The ToMM is comprised of two learning trials (Trials 1 and 2) and a retention trial. Effort was deemed adequate if performance exceeded the manual's recommended cut score.

Verbal IQ*:* The *Peabody Picture Vocabulary Test-IV* (PPVT-IV, Dunn & Dunn, 2007) requires the participant to point to one of four pictures that best represent each target word. The pointing response style was particularly suitable for this study, as there may have been elevated expressive communication difficulty in the sample. Validity supporting its use as an index of verbal intellectual functioning includes correlation with the Wechsler Adult Intelligence Scale-Third Edition (Wechsler, 1997) Verbal IQ score in university students, r = .46 (Bell, Lassiter, Matthews, & Hutchinson, 2001). Split-half reliability and test-retest reliability for Form A, which was used in this study, were acceptable, *M* alpha = .94 and .93, respectively (Dunn & Dunn, 2007). The PPVT-IV was used firstly to screen low verbal IQ, using a cut-point of two *standard deviations* below the manual's normative means. Relations of FTD with verbal IQ were also considered: The variable of interest is *PPVT-IV-Age-based standard score* (range = 20 – 160).

Performance IQ*: Matrix Reasoning* (MR) from the Wechsler Adult Intelligence Scale-Fourth Edition (WAIS-IV, Wechsler, 2008) is a relatively language-free measure of fluid reasoning; and a reliable index of performance IQ (Dugbartey et al., 1999). To perform the test, an incomplete pattern and five drawings were presented, and the participant selected the drawing that completed each pattern. A cut score of two *standard deviations* below the manual's age-based normative means was used to screen for low performance IQ. Relations of FTD with performance IQ were also considered: The variable of interest is *MR- age-based scale score* (range = 0 – 19).

Clinical interviews and inventories. The *Structured Clinical Interview for DSM-IV Axis II Personality Disorders: SCID-II, Version 2.0* (First, Spitzer, Gibbon, Williams, & Benjamin, 1994) was used to identify participants meeting DSM-IV criteria for SPD.

The *Substance Use Section of the Structured Clinical Interview for DSM-IV-TR Axis I Disorders, Research Version, Non-patient Edition* (SCID-I/NP) (First, Spitzer, M., & Williams, 2002) was used to identify lifetime DSM-IV substance use disorders. Its reliability and validity are well established (Kranzler, Kadden, Babor, Tennen, & Rounsaville, 1996; Lobbestael, Leurgans, & Arntz, 2010).

Lifetime Drug Use (LDU, Czermak et al., 2005) refers to a semi-structured interview approach to estimating an informant's total lifetime consumption of a substance. It has demonstrated high test-retest reliability (Czermak, et al., 2005). The measures of interest are lifetime units consumed of cannabis and alcohol: *LDU lifetime cannabis* and *LDU lifetime standard drinks*.

The *Severity of Dependence Scale* (SDS, Gossop et al., 1995) is a 5-item (0-almost never, 1-sometimes, 2-often, 3-nearly always) self-report questionnaire that indexes "psychological dependency" for substances over the previous month. The version adapted for

cannabis use demonstrated good internal consistency (α = .83) and test–retest reliability (ICC = .88) in a sample of young Australians (Martin, Copeland, Gates, & Gilmore, 2006): A score of 4 optimally discriminated DSM-IV cannabis dependence. An alcohol dependence version demonstrated good internal consistency (α = .92) in older Australian adults (Lawrinson, Copeland, Gerber, & Gilmour, 2007): A score of 3 optimally discriminated DSM-IV criteria for alcohol dependence. The measures of interest are total scores for cannabis (*SDS-Cannabis*) and alcohol (*SDS-Alcohol*): range = 0-15.

The *Depression Anxiety Stress Scales-21 item version* (DASS-21) is a short form of the DASS (Lovibond & Lovibond, 1995) self-report scale that provides a dimensional measurement of depression, anxiety and stress symptoms. Individual items are rated 0-3 for presence/severity over the previous week. Good to excellent reliability is reported for total and subscale scores in non-clinical (Henry & Crawford, 2005; Lovibond & Lovibond, 1995) and clinical samples (Clara, Cox, & Enns, 2001). Convergent and discriminant validity were demonstrated by comparison to prominent depression and anxiety scales (Henry & Crawford, 2005). The study used published norms for a community sample of young Australians (Crawford, Cayley, Lovibond, Wilson, & Hartley, 2011) to interpret general psychopathology. The measures of interest are *DASS-21-Depression, DASS-21-Anxiety,* and *DASS-21-Stress*: each range 0-21.

Personality measures. The SPQ (Raine, 1991) is a "yes/no" questionnaire that indexes nine traits that correspond to criteria for DSM-III-R SPD (American Psychiatric Association, 1987). Summing its 74 items provides a Total score; and the manual describes three factor scores: Factor 1, Cognitive-Perceptual Deficits, is derived by summing subscales *ideas of reference, odd beliefs/magical thinking, unusual perceptual experiences,* and *paranoid ideation*; Factor 2, Interpersonal Deficits, is indexed by summing *social anxiety, no close*

friends, *constricted affect*, and *paranoid ideation* subscales; and Factor 3, Disorganisation, is indexed by summing *odd behavior* and *odd speech* items. Similar three-factor structures are described in healthy samples in Australia (Badcock & Dragovic, 2006) and the United States (Raine et al., 1994). The SPQ has good internal reliability (Total score α = .90; subscales α = .71 to .78), test-retest reliability (*r* = .82), convergent validity (.59 to .81), and criterion validity (Raine, 1991). This study used norms derived from same-aged university students from New Zealand (*N* = 1,424, age 16-25 years, 69% female; G. M. Grimshaw, personal communication, May 19, 2014) to describe levels of schizotypal traits.

The *Borderline Personality Questionnaire* (BPQ, Poreh et al., 2006) comprises 80 "true/false" questions that provides a dimensional index of traits that correspond to the nine DSM-IV criteria for Borderline Personality Disorder (BPD, American Psychiatric Association, 1987). Its subscales are *impulsivity, affective instability, abandonment, unstable relationships, self-image, self-mutilation, emptiness, intense anger,* and *quasi-psychotic states*. BPQ Total has demonstrated good internal consistency (α = .92), test-retest reliability (*ICC* = .92), and overall diagnostic accuracy (.85) in a sample of Australian outpatients (*N* = 101, age 15-24 years, 72% female), primarily presenting with mood, anxiety, substance dependence, and eating disorders (Chanen, Jovev, McDougall, & Rawlings, 2008). We used BPQ norms from a sample of Australian Psychology undergraduates, *N* = 154; *M* age = 19.3 years, *SD* = 2.9; 76% female (Poreh, et al.) to describe trait levels in this sample.

Thought disorder scales. The TLC comprises 18 items reflecting different aspects of FTD. Raw frequency counts for each item are transformed to item scale scores with a range of four or five points (Andreasen & Grove, 1986). Interviews use semi-structured probes about a participant's current life and attitudes (see below) for 45-minutes duration or more, or item scale scores are pro-rated accordingly for shorter interviews (Andreasen & Grove). The TLC

has proved to be highly reliable (Andreasen, 1978, 1979a, 1979b; Andreasen & Grove; Davis, Simpsom, Foster, Arison, & Post, 1986). It has good "replicability" (Andreasen, 1986), adequate test-retest reliability over a 10-day period (Harvey, Earle-Boyer, & Wielgus, 1984), and its items have been shown to differentiate various psychotic disorders (Taylor, et al., 1994). External validity is supported by response to treatment studies (Cuesta, Peralta, & De Leon, 1994).

The TLI (Liddle, et al., 2002) was developed to index subtle aberrations of speech. To derive the speech sample, participants describe eight images, such as from the Thematic Apperception Test (TAT, Murray, 1943), as used in the current study, for one minute each. The descriptions and replies to questions are rated for eight items that correspond to a subset of conceptually-related TLC items. Ratings of .25 indicate abnormality of "questionable" significance, and ratings of .5, .75, and 1.0 indicate increasing severity. It has demonstrated reliability (*ICC* for individual items ranged from .60 to .93) and convergent validity (Liddle, et al., 2002).

Procedure

Participants gave written informed consent and participated in an interview to collect demographic and clinical information. ToMM, MR, and PPVT were then administered according to standard protocols, and they completed the SPQ, BPQ, DASS-21, and SDS questionnaires displayed on a monitor. They were then interviewed to collect the TLC speech sample. To begin, they were asked to speak about themselves for 5-10 minutes (e.g., "Could you tell me a little bit about what you're like, such as where you are from, what you're interested in, and things like that?"). They were not interrupted during this time except to provide non-specific prompts to continue (e.g., "Can you tell me a bit more about that"). To standardize collection of the speech sample, they then responded to a semi-structured

interview comprised of various types of questions (personal, impersonal, complex, abstract, concrete, open-ended and closed) covering topics relating to education, religious beliefs, current events, politics, sport, relationships, and family life. Then, to collect the TLI speech sample, participants described a series of eight TAT pictures according to the TLI manual. Speech samples were recorded and rated during the interview and again later, to confirm accuracy. Finally, a clinical interview collected information using the SPD section of the SCID-II, the substance use section of the SCID-I/NP, and the LDU questionnaire.

Statistical Approaches

To evaluate the hypothesis that the sample would demonstrate elevated FTD, we compared scores on the TLC and TLI from our sample to findings from previous research. To evaluate our main hypothesis that the dimensional structure of FTD in our sample would resemble dimensions reported in patients with schizophrenia, we compared PCA-derived solutions from our study to those reported previously for patients with schizophrenia; specifically we expected two- or three-component solutions. Correlations tested the hypotheses that conceptually-related TLC and TLI components would correlate; FTD would relate to psychosis-like experiences (specifically, TLC and TLI component scores would positively correlate with SPQ Cognitive-Perceptual Factor and BPQ *quasi-psychotic states* scores); and FTD would be associated with general cognitive dysfunction (specifically, TLC and TLI component scores would negatively correlate with PPVT-IV and MR scores).

One-tailed tests were used given the predicted direction of these relationships; and critical p-values were set using the Benjamini-Hochberg (1995) approach to control for the false discovery rate (with overall $\alpha = .05$). This approach was selected as it offers relatively low reduction of power. Differences between group means were calculated using software made available by Uitenbroek (1997); and effect size estimates were derived using software

obtained from Lenhard and Lenhard (2015). Data was analyzed using Statistical Package for the Social Sciences Version 21.

With regard to sample size for PCA, many researchers regard a subject-to-variable ratio of 10 as a general rule-of-thumb; and a survey has shown that 63% of published studies report a ratio of 10 or less (Costello & Osborne, 2005). As such, a sample of 90 is sufficient to perform PCA on the TLC and TLI data (ratios of 10 and 18, respectively). Power analysis, performed using software obtained from Faul, Erdfelder, Buchner, and Lang (2009), indicated the sample size suitable (adequate $n = 88$; power = .90) to detect moderate correlations ($r = .30$, $\alpha = .05$, one-tailed), as is typically reported in the relevant neuropsychological literature (Kerns & Berenbaum, 2002).

Preliminary investigation of data. Inspection of Q-Q plots and skewness, kurtosis, and Shapiro-Wilk tests ($p < .05$) indicated that DASS-21 Depression and Anxiety subscale scores, LDU scores (cannabis and alcohol), and SDS scores (cannabis and alcohol) were substantially positively skewed: Distributions were sufficiently normalized ($\alpha < .05$) following square root transformation. Scores for two univariate outliers on education and Anxiety were Winsorised. Visual inspection of scatterplots of relevant combinations of variables did not indicate curvilinearity.

Prior to performing PCA, the suitability of combining data from the two recruitment locations and across sex was investigated by comparing groups using Independent-samples t-test (two-tailed) on a range of demographic and other variables (sex, age, mood, schizotypal traits, borderline traits, and IQ). The only differences were that the Melbourne group reported slightly more education and fewer stress symptoms, $t(90) = 2.24$, $p = .03$ and $t(88) = 2.02$, $p = .05$, respectively; and the females reported slightly more education, $t(90) = -2.07$, $p = .04$. However, the magnitude of the differences in the means was small, $\eta^2 = .05$, .04, and .04,

respectively. Hence, the data were combined and considered homogeneous for the purpose of the study.

***Preliminary investigation of the TLC data for PCA*.** Nine items rated as present in less than 10% of participants were omitted from analysis, in keeping with previous research (Berenbaum, et al., 1985; Nagels, et al., 2013): These were *distractible speech, clanging, neologisms, echolalia, incoherence, poverty of speech, illogicality, blocking,* and *stilted speech*. A combination of visual inspection of graphs, assessment of skewness and kurtosis ($p < .05$), and formal tests (Shapiro-Wilk $p < .05$) indicated eight items were substantially positively skewed. Pro-ration and statistical transformation (logarithmic and square root) improved distributions; and outliers were Winsorised: *tangentiality, word association, perseveration, circumstantiality,* and *pressure of speech* remained positively skewed. Comparison of PCA solutions with and without transformations, revealed comparable solutions, but the solution with transformed variables had simpler structure. Thus, PCA is reported for the transformed data.

The suitability of the transformed data for the final PCA was also assessed. Pearson product-moment correlation between items indicated no extreme singularity (all $r < .80$ and determinant = .07). All items correlated with one or more items > .3 ($p \leq .001$), suggesting reasonable "factorability". The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was "good" (.8), as was also indicated by small values among the negatives of partial correlations in the anti-image matrix and by Bartlett's Test of Sphericity: $\chi^2(36) = 226.85$, $p < .001$. KMO values for items were all well above .50, supporting their inclusion in the analysis. Communalities were well above .3, and are presented in Table 4. Preliminary Oblimin rotation indicated that correlations between components were below .32, supporting Varimax rotation.

***Preliminary investigation of the TLI data for PCA*.** Three participants did not complete the TLI. The data from the remaining 89 participants was examined as above, resulting in the exclusion of three items: *distractibility*, *peculiar sentences* and *peculiar logic*. Transformations (logarithm and square root) and Winsorising of outliers produced sufficiently normal distributions ($\alpha < .05$). Comparison of PCA, with and without transformations, revealed comparable solutions.

Suitability of the transformed data for the final PCA was also evaluated. Examination of singularity (all correlations < .80 and determinant = .58), small values among the negatives of partial correlations in the anti-image matrix and Bartlett's Test of Sphericity, $\chi^2(10) = 46.98$, $p < .001$, were satisfactory. The KMO measure of sampling adequacy was adequate (.48). The KMO value for *perseveration of ideas* was low (.42), but communalities were well above .3 for all items except *loose speech*: These are presented in Table 5. Preliminary Oblimin rotation revealed all correlations between components were below .32, supporting Varimax rotation.

Results

Basic and Clinical Descriptives

Table 1 summarizes basic demographic and clinical descriptives for the 92 participants. In brief, this was a sample of young adults with roughly equal numbers of males and females ($n = 53$ and 39, respectively), about 10 years of formal education, and average-range IQ. Thirteen participants (14%) reported ongoing medical conditions and were in receipt of medication. Six (7%) were being treated for depressive disorder. Two reported hyperthyroidism (one with Graves disease) controlled with medication. One participant reported insulin type-1 diabetes, and another was taking medication for hypertension. Two participants were in receipt of medication for opioid dependency. Fifteen (16%) participants

reported a family history of schizophrenia (1st degree = 9, 2nd degree = 6). One participant reported a mother with bipolar disorder, and a father with depression-related psychosis.

Substance abuse and dependence were prevalent with 57 participants (62%) meeting DSM-IV criteria: previous abuse (alcohol 8%, cannabis 1%, sedative 1%), previous dependence (alcohol 15%, cannabis, 36%, sedative, 4%, stimulant 17%, opioid 7%, cocaine 2%, hallucinogen 2%, inhalant 1%), current abuse (alcohol 2%), and current dependence (alcohol 3%, cannabis 16%, stimulant 8%, opioid 1%). Twenty participants (22%) had scores at or above the SDS cut-point of 4 shown to optimally discriminate DSM-IV cannabis dependence in adolescents (Martin, et al., 2006), and 18 participants (20%) had scores at or above the cut point of 3 that optimally discriminates alcohol dependence in adults (Lawrinson, et al., 2007).

General psychological distress was elevated. DASS-21 Depression, Anxiety, and Stress subscale scores were at, or above, the normative 95th centile (Crawford, et al., 2011) for 16 (18%), 19 (21%), and 11 (12%) participants, respectively. Schizotypal and borderline traits were elevated. Independent-samples t-test revealed greater SPQ Total score for the current sample (M = 34.97, SD = 15.33) than the normative comparison group (see *Methods*, N = 1424, M = 23.91, SD = 12.28): $t(98.2) = 6.78$, $p < .001$, two-tailed. The magnitude of the difference (mean difference = 11.06, 95% CI: 7.86 to 14.26) was large, $d_{Cohen} = .89$. SPQ Total for 39 participants (42%) fell above the normative 90th centile; and 14 (15%) participants met DSM-IV SPD criteria using the SCID. Similarly, BPQ Total for 37 (40%) participants fell above the normative 90th centile (Poreh, et al., 2006). BPQ Total for eight (9%) participants exceeded the cut-point of 56, shown to discriminate criteria for DSM-IV BPD (Chanen, et al., 2008).

Internal consistency estimates for SPQ Total, Cognitive-Perceptual, Interpersonal, and Disorganised were excellent, Cronbach α = .94, .90, .91, and .84, respectively; and subscale mean inter-item correlations ranged from .22 to .42. Internal reliability for BPQ Total (Cronbach's α = .95); and BPQ subscale mean inter-item correlations ranged from .20 to .42.

Table 1

Sample Demographic, Clinical and Psychopathology Characteristics (N = 92 all, except DASS-21 scores n = 90)

Characteristic	*Mdn*	range	*M*	*SD*	95% CI of *M*
Age (years)	20	16 - 25	20.1	2.2	19.6, 20.6
Education (years)	10	7 - 15	10.0	1.5	9.7, 10.3
LDU Cannabis (kg)	0.4	0 - 17.6	1.8	3.1	1.1, 2.5
LDU Alcohol (1000 standard drinks)	3.0	0 - 56.6	5.7	9.2	4.5, 8.8
SDS - Alcohol	0	0 - 11	1.2	2.3	0.8, 1.9
SDS - Cannabis	0	0 - 11	1.8	2.9	1.3, 2.6
WAIS-IV MR (age scale score)	10	4 - 14	9.7	2.4	9.2, 10.2
PPVT-IV (age standard score)	94	74 - 123	94.7	10.9	92.4, 96.9
DASS-21 Total	17	0 - 55	17.9	11.3	15.5, 20.3
Depression sub-scale	5	0 - 21	5.9	5.1	4.8, 7.0
Anxiety sub-scale	4	0 - 18	4.8	3.5	4.0, 5.5
Stress sub-scale	7	0 - 17	7.3	4.3	6.4, 8.2
SPQ Total	36	0 - 72	35.0	15.3	31.8, 38.1
Cognitive-Perceptual sub-scale	13	0 - 32	14.4	7.6	12.8, 16.0
Interpersonal sub-scale	9	0 - 31	16.2	8.0	8.0, 9.8
Disorganised sub-scale	17.5	0 - 16	8.9	4.3	14.5, 17.8
BPQ Total	36	4 - 68	34.5	17.0	31.0, 38.1

Note. CI of *M* = confidence interval of the sample mean; LDU = Lifetime Drug Use (Czermak, et al., 2005); SDS = Severity of Dependence Scale (Gossop, et al., 1995); WAIS-IV MR = Matrix Reasoning from the Wechsler Adult Intelligence Scale-Fourth Edition (Wechsler, 2008); PPVT-IV = Peabody Picture Vocabulary Test-IV (Dunn & Dunn, 2007); DASS-21 = (Lovibond & Lovibond, 1995); SPQ = Schizotypal Personality Questionnaire (Raine, 1991); BPQ = Borderline Personality Questionnaire (Poreh, et al., 2006).

Formal Thought Disorder: Severity and Dimensional Structure

***Frequency and severity of TLC ratings*.** Table 2 reports TLC scores for our sample, along with scores previously reported for healthy adults and patients with schizophrenia. Scores for our sample generally ranged between those for healthy adults and patient samples. "Clinically-elevated" levels (item score >.25) were observed for 63 (68%) participants; and mean scores for *tangentiality, derailment,* and *loss of goal* were comparable to persons with schizophrenia. The current sample demonstrated more *word approximations* and *self-reference*, and less *poverty of speech* than the patient samples. No participant evidenced *distractibility*, *clanging*, *neologisms*, or *echolalia*; and fewer than 10% of them exhibited *incoherence, poverty of speech*, *peculiar logic, blocking,* or *stilted speech*. Only sixteen participants (17%) demonstrated no disturbance on the TLC.

Table 2

Frequency and Severity of TLC Scores for Schizotypal, Control, and Schizophrenia Samples

	Frequency			Severity					
	% of ratings > 1			*M* (*SD*)			*Mdn* (*I-QR*)		
Study	1	2	2	1	3	4	1		
Sample	Sy	Sz	healthy controls	Sy	Sz	Sz	Sy		
TLC item									
Poverty of Speech	**4**	30	5	**0.14 (0.46)**	0.47 (0.84)	0.94 (1.10)	**0.0**	**(0.0,**	**0.0)**
Poverty of Content	**11**	28	1	**0.64 (0.72)**	0.76 (1.09)	1.25 (1.21)	**1.0**	**(0.0,**	**1.0)**
Pressure of Speech	**8**	20	6	**0.30 (0.62)**	0.36 (0.65)	0.47 (0.75)	**0.0**	**(0.0,**	**0.0)**
Distractible Speech	**0**	6	3	**0.00 (0.00)**	0.02 (0.15)		**0.0**	**(0.0,**	**0.0)**
Tangentiality	**15**	20	2	**0.59 (0.92)**	0.55 (0.84)	1.83 (1.26)	**0.0**	**(0.0,**	**1.0)**
Derailment	**45**	62	32	**1.53 (1.41)**	1.22 (1.33)	1.64 (1.38)	**1.0**	**(0.0,**	**3.0)**
Incoherence	**5**	30	0	**0.17 (0.62)**	0.33 (0.90)	0.74 (1.15)	**0.0**	**(0.0,**	**0.0)**
Illogicality	**1**	30	0	**0.03 (0.23)**	0.42 (0.87)		**0.0**	**(0.0,**	**0.0)**
Clanging	**0**	4	0	**0.00 (0.00)**	0.00 (0.00)		**0.0**	**(0.0,**	**0.0)**
Neologisms	**0**	0	0	**0.00 (0.00)**	0.02 (0.15)		**0.0**	**(0.0,**	**0.0)**
Word Approximation	**9**	6	2	**0.30 (0.68)**	0.00 (0.00)		**0.0**	**(0.0,**	**0.0)**
Circumstantiality	**7**	16	6	**0.33 (0.80)**	0.04 (0.21)	1.14 (1.06)	**0.0**	**(0.0,**	**0.0)**
Loss of Goal	**29**	30	18	**1.02 (1.09)**	0.71 (0.92)	1.32 (1.09)	**1.0**	**(0.0,**	**2.0)**
Perseveration	**4**	24	8	**0.17 (0.53)**	0.13 (0.64)		**0.0**	**(0.0,**	**0.0)**
Echolalia	**0**	0	0	**0.00 (0.00)**	0.07 (0.33)		**0.0**	**(0.0,**	**0.0)**
Blocking	**0**	0	1	**0.01 (0.10)**	0.06 (0.33)		**0.0**	**(0.0,**	**0.0)**
Stilted Speech	**0**	2	1	**0.01 (0.10)**	0.02 (0.15)		**0.0**	**(0.0,**	**0.0)**
Self-reference	**26**	0	1	**0.75 (0.95)**	0.16 (0.42)		**0.0**	**(0.0,**	**2.0)**
Total Score				**6.01 (5.07)**			**5.0**	**(2.0,**	**10.8)**
n	92	50	94	92	45	142	92		

Note. **Bold** = present study. TLC = Scale for the Assessment of Thought, Language and Communication (Andreasen, 1978); I-QR = Inter-quartile range; Sy = current sample with schizotypal traits; Sz = patients with schizophrenia; 1 = present study; 2 = Andreasen and Grove (1986); 3 = Andreasen (1979b); 4 = Harvey et al. (1992).

***Frequency and severity of TLI ratings*.** Table 3 reports TLI ratings for the current sample, along with ratings for healthy adults and patients with schizophrenia from previous research. Mean ratings for *poverty of speech* and *perseveration of ideas* were similar to the patient groups, while the remaining item levels were similar to healthy adults. *Distractibility* was not observed, and *peculiar sentences* and *peculiar logic* were infrequent (< 10% of sample). Only seven participants (8%) had ratings of zero for all items.

Table 3

Frequency and Severity of TLI Scores for Schizotypal, Control, and Schizophrenia Samples

	Mdn (*I-QR*)	range	*M* (*SD*)	*95%* CI of *M*	*M*	*M*
Study	1	1	1	1	2	2
Sample	current study with elevated schizotypal traits				healthy controls	Sz
TLI item						
Poverty of Speech	**1.00 (0.0 – 3.0)**	**(0.00 – 7.75)**	**1.76 (2.06)**	**1.33-2.19**	0.2	1.0
Weakening of Goal	**0.00 (0.0 – 0.3)**	**(0.00 – 2.00)**	**0.14 (0.33)**	**0.07-0.21**	0.1	0.3
Perseveration of Ideas	**0.50 (0.2 – 1.1)**	**(0.00 – 4.50)**	**0.74 (0.85)**	**0.57-0.92**	0.1	0.5
Loose Speech	**0.00 (0.0 – 0.0)**	**(0.00 – 0.75)**	**0.06 (0.14)**	**0.03-0.09**	0.1	0.2
Peculiar Use of Words	**0.00 (0.0 – 0.0)**	**(0.00 – 1.00)**	**0.08 (0.19)**	**0.04-0.11**	0.1	0.6
Peculiar Sentences	**0.00 (0.0 – 0.0)**	**(0.00 – 1.00)**	**0.03 (0.13)**	**0.00-0.05**	0.3	1.2
Peculiar Logic	**0.00 (0.0 – 0.0)**	**(0.00 – 1.75)**	**0.04 (0.21)**	**0.00-0.09**	0.0	0.2
Distractibility	**0.00 (0.0 – 0.0)**	**(0.00 – 0.00)**	**0.00 (0.00)**	**0.00-0.00**	0.0	0.0
n		89			24	24

Note. **Bold** = present study. TLI = Thought and Language Index (Liddle, et al., 2002); I-QR = Inter-quartile range; CI of *M* = confidence interval of the sample mean Sz = patients with schizophrenia; 1 = present study; 2 = Liddle et al. (2002).

PCA of the TLC. Table 4 describes a three-component solution that explains 63% of the variance: 22.8%, 22.6% and 17.6% after rotation. A range of criteria were applied to determine the optimal number of components. Eigenvalues fell below 1.00 for a fourth component (.86), indicating a three-component solution. Two, three and four component solutions following Varimax and Oblimin rotation were also visually inspected, and a three-component solution following Varimax rotation was ultimately selected, since this provided the most interpretable result with respect to previous research and offered a solution with relatively simple structure.

Component 1, labelled Disorganisation, appeared to reflect difficulty maintaining goal in speech: *loss of goal*, *derailment*, and *tangentiality*. Its reliability was supported by a strong correlation between *loss of goal* and *derailment* ($r = .73$, $p < .001$), and their weak correlation with items loading heavily on Components 2 and 3. Component 2, labelled Verbosity, was primarily comprised of *circumstantiality*, *pressure of speech*, and *word approximation*. Component 3, labelled Emptiness, appeared to reflect paucity of thought: *poverty of content of speech* and *perseveration*. Each component had two or more items with loadings exceeding statistical significance (.54, $\alpha < .01$, two-tailed) for the sample size (Stevens, 2009), indicating the reliability of the component structure. The solution had features of "simple structure", with seven items loading highly on only one component, and all components had two or more strong loadings. Internal-reliability was "optimal" for the components (Table 4). Skewness, kurtosis, and Shapiro-Wilk tests indicated non-normal distributions for Component 2 and 3: Square root (Component 1) and logarithm transformations (Components 2 and 3) sufficiently normalized distributions for follow-up parametric analyses. Item communalities, eigenvalues, and internal consistencies are presented in Table 4.

Table 4

Component Loadings Following Principal Components Analysis with Varimax Rotation of the TLC (N = 92)

TLC Item	1 Disorganization	2 Verbosity	3 Emptiness	Communality
Loss of Goal	**.89**	.17	-.01	.83
Derailment	**.72**	.**47**	.15	.77
Tangentiality	**.59**	.04	.36	.48
Circumstantiality	.01	**.76**	.23	.63
Pressure of Speech	.23	**.70**	.06	.55
Word Approximation	.21	**.70**	.04	.54
Poverty of Content	.33	-.09	**.77**	.70
Perseveration	-.14	.34	**.71**	.64
Self-reference	.40	.31	**.53**	.53
eigenvalue	3.42	1.17	1.08	
mean inter-item correlation	.49	.39	.32	

Note. Component loadings > .40 are in boldface. TLC = Scale for the Assessment of Thought, Language and Communication (Andreasen, 1978).

PCA of the TLI. A two-component solution was selected explaining 58% of the variance: 32.7% and 25.7%, for Components 1 and 2, respectively (Table 5). The optimal number of components was determined using several criteria. PCA revealed two components with eigenvalue exceeding 1.00. The third component's eigenvalue was (.97), and it was comprised of only a single item with a loading greater than .20. Hence the two-component solution was selected.

Component 1 was labelled Negative, as its items appeared to reflect poverty of thought and speech. The second component was labelled Idiosyncratic, as its highest loading item was thought to reflect a peculiar use of language. Component 1 items, *poverty of speech* and *weakening of goal,* strongly correlated ($r = .55$, $p < .001$, one-tailed), while *weakening of goal* only weakly correlated with *perseveration of idea* from Component 2, indicating that Component 1 was reliable. Each component had two items loading greater than .54, also supporting reliability of the component structure (Stevens, 2009). The solution had features of simple structure, with four items loading strongly on only one component, and both components having two strong loadings. Inspection of skewness, kurtosis, and Shapiro-Wilk tests ($p < .05$) indicated that the component scores departed substantially from normality. Logarithmic transformations sufficiently normalized their distributions for follow-up parametric analyses. Item communalities, eigenvalues, and internal consistencies are presented in Table 5.

Table 5

Component Loadings Following Principal Components Analysis with Varimax Rotation of the TLI (n = 89)

TLI Item	1 Negative	2 Idiosyncratic	Communality
Weakening of Goal	**.89**	.06	.80
Poverty of Speech	**.83**	-.18	.72
Peculiar Use of Words	-.15	**.78**	.63
Perseveration of Ideas	.36	**.69**	.60
Looseness	-.10	**.41**	.18
eigenvalue	1.63	1.28	
mean inter-item correlation	.55	.12	

Note. Component loadings > .40 are in boldface. TLI = Thought and Language Index (Liddle, et al., 2002).

Relationships Between TLC and TLI Component Scores

Table 6 reports inter-correlations of TLC and TLI components. Following correction for the false discovery rate, only weak relationships were evident; and inter-correlations were no stronger if we had used the three-component TLI solution. There were positive relationships between TLC Verbosity and TLI Idiosyncratic; and between TLC Emptiness and TLI Negative. Of note, TLC Verbosity and TLI Negative correlated *negatively*.

Table 6

Pearson Correlations Between TLC and TLI Components (n = 89)

	TLI Component	
	1 Negative *r (p)*	2 Idiosyncratic *r (p)*
TLC Component		
1 Disorganisation	.01 (.47)	.17 (.05)
2 Verbosity	**-.28 (.004)**	**.25 (.01)**
3 Emptiness	**.23 (.02)**	.06 (.29)

Note. **Bold** = significant following Benjamini-Hochberg step-up procedure ($\alpha = .05$).

Relationships Between TLC and TLI Component Scores and Psychosis-like Traits

Correlations between TLC and TLI components and schizotypal and borderline traits are reported in Table 7. While no correlations reached significance following Benjamini-Hochberg step-up procedure, there was a strong tendency for TLC Disorganisation and Emptiness to be related to reporting more aberrant psychosis-like experiences indexed consistently by both the SPQ Cognitive-Perceptual and BPQ *quasi-psychotic states* scores. In contrast, no relations with TLI scores approached significance.

Relationships Between TLC and TLI Component Scores and IQ Measures

Table 7 also reports relationships between TLC and TLI components and verbal and performance IQ. After controlling for the false discovery rate, demonstrating more TLI Negative symptoms was significantly related to lower IQ. Trend relationships were also suggested such that better verbal IQ associated with lower TLC Disorganisation, TLC Emptiness and TLI Idiosyncratic scores but higher TLC Verbosity scores.

Relationships Between TLC and TLI Component Scores and SPQ Odd Speech

Correlations between TLC and TLI components and the SPQ odd speech subscale revealed no significant relationships, all $p > .40$, two-tailed.

Post-hoc Investigations

Post-hoc investigations revealed non-significant relationships between the TLC/TLI components and each of SPQ Disorganisation, Interpersonal Deficits, and Total. We also investigated relationships between BPQ Impulsivity and each of the TLC/TLI components and the IQ measures. The only significant relationship was that BPQ Impulsivity was associated with TLC Disorganisation ($r = .25$, $p = .02$, 2-tail).

Table 7

Pearson Correlations Between TLC and TLI Components, Psychosis-like Traits and IQ Measures

TLC/TLI	Component	SPQ Cognitive-Perceptual Factor *r (p)*	BPQ Quasi-Psychotic States *r (p)*	PPVT-IV (Verbal IQ) *r (p)*	MR (Performance IQ) *r (p)*
TLC	1 Disorganization	.23 (.01)	.23 (.01)	-.17 (.05)	-.09 (.20)
(*n* = 91)	2 Verbosity	.01 (.47)	.03 (.39)	.18 (.05)	.09 (.19)
	3 Emptiness	.20 (.03)	.25 (.01)	-.16 (.07)	-.09 (.21)
TLI	1 Negative	.02 (.42)	.10 (.18)	**-.32 (.001)**	**-.38 (<.001)**
(*n* = 88)	2 Idiosyncratic	.03 (.38)	.10 (.18)	-.15 (.08)	-.04 (.37)

Note. **Bold** = significant following Benjamini-Hochberg step-up procedure (α = .05). TLC = Thought, Language and Communication Scale; TLI = Thought and Language Index; SPQ = Schizotypal Personality Questionnaire (Raine, 1991); BPQ = Borderline Personality Questionnaire (Poreh, et al., 2006); PPVT-IV = Peabody Picture Vocabulary Test-IV (Dunn & Dunn, 2007); MR = Matrix Reasoning from the Wechsler Adult Intelligence Scale-Fourth Edition (Wechsler, 2008).

A final comment before the Discussion, is that we also performed a PCA of both the TLC and the TLI ratings combined. This resulted in a best fitting five-component structure akin to those reported above, with no component comprised of strongly loading items from both scales. That this additional analysis revealed these five relatively independent components is generally consistent with the pattern of weak TLC-TLI intercorrelations reported above.

Discussion

Previous schizophrenia research has revealed some inconsistencies concerning the dimensional structure of FTD. These inconsistencies may reflect different samples and possible confounds associated with clinical research. We sought to shed light on this stream of research using the continuum approach which regards schizophrenia as the extreme end-point of a psychosis continuum that also extends to schizotypal traits at the sub-clinical end. To avoid limitations of most previous schizotypy research, which has relied primarily on undergraduate samples, we performed principal components analysis (PCA) on FTD ratings from a community-based sample of young adults attending services for homeless youth. We also used two FTD scales, to index subtle FTD such as may occur in a non-clinical sample (the TLI) and to provide a link to clinical FTD research (the TLC). We hypothesized: 1) the sample would demonstrate elevated FTD using the TLC and TLI; 2) PCA would reveal two- or three-component solutions similar to those reported in patients with schizophrenia; 3) conceptually-related TLC and TLI components would correlate; 4) FTD would be associated with psychosis-like experiences; and 5) FTD would demonstrate a link to general cognitive dysfunction, indexed by IQ scores.

Severity and Frequency of FTD

With respect to the TLC, ratings for the sample exceeded those reported for healthy control groups (Andreasen & Grove, 1986; Liddle, et al., 2002), and approached, or were commensurate with patient groups with schizophrenia (Andreasen, 1979b; Andreasen & Grove; Harvey, et al., 1992; Liddle, et al.). Specifically, the sample demonstrated a strong tendency to respond to questions obliquely and drift off topic, as is described in schizophrenia (Andreasen & Grove; Liddle, et al.). Responses to questions were characterized by paucity of information and incoherence, at levels between healthy control and patient groups. The sample referred apparently neutral topic back to themselves, more frequently than reported in schizophrenia by some studies (Andreasen, 1979b; Cuesta & Peralta, 2011), but not others (Bazin, et al., 2002; Mazumdar, Chaturvedi, Sinha, & Gopinath, 1991; Salavera, Puyuelo, Antoñanzas, & Teruel, 2013), possibly reflecting low reliability for the TLC *self-reference* item (Andreasen, 1979a). Descriptions of TLI picture stimuli were relatively brief, possibly related to the stimuli which participants described as disturbing. Overall though, poverty of speech assessed using the TLC was limited in this young sample, possibly reflecting the relative absence of a sub-clinical "negative syndrome" characteristic of FTD as seen in chronic schizophrenia.

The TLI provided less evidence of FTD than the TLC: This was surprising given that the TLI was designed to index subtle aberrancies of speech in non-clinical samples. Similarly, Weinstein, McKay and Ngan (2008) reported no evidence of "clinically-significant" TLI-rated abnormality (item score > 0.25) in their sample of university students and staff. Also, the TLI normative study found that "clinically-significant" disorganisation items were very rare in their non-clinical controls (Liddle, et al., 2002), and they reported no difference in mean number of disorganisation phenomena of "questionable abnormality" (item score =

0.25) between controls and patients with schizophrenia without "definite disorganisation" features. This apparent discrepancy between the TLC and TLI may be due to the TLI's relatively structured and test-like format, which may assist to organise speech: particularly as idiosyncratic and unusual responding on semantic tasks has been shown to increase with less structure (the repetition of instructions) in undergraduates with elevated schizotypal traits (Miller & Chapman, 1983). On the other hand, it may be this relatively structured format of the TLI that better revealed those individuals who had more marked difficulty generating speech (even when provided with a focus). Thus, if the aim is to better understand the cognitive and neural correlates of negative FTD using the continuum approach, the TLI may better tap this dimension of negative FTD. If instead the aim is to better understand the correlates of a more fine-grained model of distinct FTD dimensions that also comprise disorganisation and verbosity, then the TLC may be the more useful measure, as discussed below.

Dimensionality of FTD

PCA using the more reliably observed TLI and TLC items (≥ 10% prevalence) identified two or three components respectively that explained about 60 percent of the variance from each scale. PCA of the TLC (9 items) produced three components, which is generally consistent with research of patients with schizophrenia (Andreasen, 1979b; Andreasen & Grove, 1986; Andreou, et al., 2008; Bazin, et al., 2002; Berenbaum, et al., 1985; Cuesta & Peralta, 1999, 2011; Harvey, et al., 1992; Nagels, et al., 2013; Ott, et al., 2002; Peralta, et al., 1992; Taylor, et al., 1994). The first, comprised primarily of oblique replies and drifting off topic, was labelled Disorganisation, in keeping with prior research (for example, Andreou, et al.; Bazin, et al.; Nagels, et al.; Peralta, et al.). Peralta et al. suggested that tangentiality and loss of topic of speech reflect Bleuler's (1911/1950) concept of "loosening

of associations". The second component, labelled Verbosity, was comprised primarily of pressure of speech, excess detail, and peculiar word use. We felt that these items were conceptually-related by overproduction of thought and speech; and shared similarity with the deregulated verbal productivity components described by other studies (Andreou, et al.; Bazin, et al.). The third component, Emptiness, comprised primarily of paucity of content, perseveration, and self-referencing items, and resembles similar 'empty' components described in previous studies (Andreou, et al.). We were cautious about referring to this component as "negative"; however, because poverty of quantity of speech was not included in the TLC PCA analysis, as it was in the TLI PCA analysis.

In contrast, PCA of the TLI (5 items) best supported a two-dimensional FTD model consistent with some previous research using this instrument (Liddle, et al., 2002). The first component was interpreted to reflect diminished thought and speech, as it was comprised primarily of brevity and paucity of information. We labelled it Negative, as it seemed conceptually closest to negative FTD. The second component, labelled Idiosyncratic, consisted principally of peculiar word use and repetitiveness.

Associations Between TLC and TLI Components

As expected, conceptually-related components from the TLC and TLI were associated in expected directions: TLC Emptiness positively related with TLI Negative scores; TLC Verbosity scores positively related with TLI Idiosyncratic scores; and TLC Verbosity score was *negatively* related to TLI negative score. While these relationships indicate concordance across conceptually-linked constructs on these scales, correlations were modest in our sample. Also, Liddle, Ngan, Cassie, et al. (2002) reported relatively small relationships between conceptually-related subscales from the TLI and the positive FTD subscale of the Scale for the Assessment of Positive Symptoms and the alogia subscale from the Scale for the

Assessment of Negative Symptoms (Andreasen, 1987), in inpatients with schizophrenia several weeks following treatment with antipsychotic medication (n = 38). As discussed above, some of this disparity may relate to differences between the TLC and TLI, notably in their divergent approaches to eliciting the speech samples, which may influence their sensitivity to detect subtypes of FTD in different populations.

Associations of TLC/TLI Components with Psychosis-like Traits

TLC components (Disorganisation and Emptiness) were linked specifically to psychosis-like traits indexed by the SPQ and the BPQ in our non-clinical sample. This is consistent with previous research reporting elevated levels of objectively-rated communication disturbances associated with raised levels of positive schizotypal traits in undergraduates (Coleman, et al., 1996). In contrast, we found no significant relations between the TLI components and psychosis-like traits. Similarly, Weinstein, McKay and Ngan (2008) found no difference in severity of FTD using the TLI between groups of undergraduates with high or low levels of positive schizotypal traits.

Associations of TLC/TLI Components with IQ Measures

In this case, however, it was a TLI component rather than the TLC components that correlated most strongly with IQ measures. More specifically, TLI Negative component scores correlated negatively and moderately with both Peabody Picture Vocabulary Test-IV (PPVT-IV) and WAIS-IV Matrix Reasoning (MR) performance. It is noted, however, that similar directions of relationships were also seen for the TLC Disorganisation and Emptiness scores, although these were only at a trend level for the verbal IQ measure.

Perhaps of more interest, is the general pattern for the TLC Verbosity component which was distinctive in being related to higher IQ, although with regard to verbal and not performance IQ. The reason for this association is unclear, but we speculate as a possibility

that this relationship may relate to hypomanic traits, which were not assessed in our sample, possibly reflecting a degree of affective dysregulation as is characteristic of some mood disorders, externalizing disorders, and borderline personality disorder (for discussion, see Kwapil et al., 2000). Studies have linked hypomanic traits with improved functioning in community samples. Among this evidence, Stringaris, Castellanos-Ryan, Banaschewski, et al. (2014) took a dimensional approach to mania symptoms and administered the Development and Well-being Assessment (Ford, Goodman, & Meltzer, 2003) to community-based youth (N = 1755); and found that higher verbal IQ was linked to an Exuberance dimension, characterized by high energy and cheerfulness; and to which talking fast contributed. Similarly, Holtmann, Portner, Duketis, et al. (2009) found that in their sample of nonclinical adolescents (N = 294), fewer self-reported peer problems were associated with more "active-elated"-type hypomanic features including talking more and thinking faster using the Hypomania Checklist-32 (Angst et al., 2005). Also, hypomanic traits have been associated with divergent thinking and creativity in non-clinical youth (Furnham, Batey, Anand, & Manfield, 2008); and have been linked to cognitive flexibility in undergraduates induced into a positive mood (Fulford, Feldman, Tabak, McGillicuddy, & Johnson, 2013). There is some evidence as well linking hypomanic traits with schizotypal traits and psychosis-like experiences (Kwapil, et al.); and genetic links between hypomanic facets of positive schizotypal traits have been described (Macare, Bates, Heath, Martin, & Ettinger, 2012). Thus, we wonder whether hypomanic traits, mild euphoria, and "verbal drive" may play a role in the observed relationship between greater TLC Verbosity score and higher verbal IQ in our sample. "It appears also possible that these relations might reflect another dimension of schizotypal traits proposed by some schizotypy researchers - Impulsive Nonconformity/Psychoticism - that the SPQ does not index. However, we found no evidence

of such relations using the BPQ measure of Impulsivity. Nevertheless, we acknowledge that there may be other personality traits in our sample with elevated schizotypal traits that were not measured by the inventories that were used in this study, and that may have accounted for the relationship between TLC Verbosity and IQ."

Future Research

In order to further examine the dimensionality of FTD, we suggest that future continuum research investigate correlates of FTD in similar samples of persons with elevated schizotypal traits. In particular, as we found a multidimensional symptom structure underlying FTD in our sample; and as different dimensions of FTD have been differentiated by different patterns of cognitive dysfunction in persons with schizophrenia (Asarnow & MacCrimmon, 1982; Barch & Berenbaum, 1996; Harvey, et al., 1988; Harvey & Serper, 1990; Walker & Harvey, 1986), the aim of investigating cognitive correlates of different FTD dimensions in samples with elevated schizotypal traits should also be pursued. In our sample, the TLC and the TLI demonstrated unique strengths; and we suggest the utility of employing both measures together for future neuropsychological research: The TLI seemed more sensitive to a negative dimension of FTD and IQ in our sample, while the TLC was sensitive to symptoms of disorganised FTD that were also related to psychosis-like experiences. The relationship between verbosity-type FTD and cognitive functioning also needs further exploration, as increased verbosity factor scores on the TLC were linked to stronger IQ in our sample.

Future continuum research would also likely benefit from examining the cognitive characteristics of FTD, using a sampling strategy similar to that used in this study. Our sample, recruited from services for homeless youth, demonstrated prominent FTD; and given the nature of our recruitment strategy, a sample of this type is more likely to report significant psychosocial adversity (e.g., homelessness, unemployment, substance use, early trauma) as is

also reported in general-community samples with schizotypal traits (Lentz, Robinson, & Bolton, 2010; Velikonja, et al., 2015), and is consistent with the very high levels of co-morbid substance dependence, elevated psychological distress, and relatively low educational attainment in the current sample.

Limitations and Strengths

Given the unexpected findings concerning TLC Verbosity and our speculations about the role of mania above, a limitation is that we did not include a hypomanic trait scale in our study. We had focused on the SPQ for obvious reasons; and the BPQ owing to the reported overlap between schizotypal and borderline personality traits in general-community adolescent (Badoud et al., 2014) and undergraduate samples (Fonseca-Pedrero, Lemos-Giráldez, Paino, Sierra-Baigrie, & Muñiz, 2012), and the elevated prevalence of psychotic symptoms (20-50%) reported by patients with Borderline Personality Disorder (for reviews, see Balaratnasingam & Janca, 2015; Gras, Amad, Thomas, & Jardri, 2014). This additional focus on manic traits is an important direction for future research, as different dimensions of FTD have been shown to differentiate patients with mania from those with schizophrenia: mania has been distinguished by greater TLC *pressure of speech, distractibility,* and *circumstantiality*; and schizophrenia has been differentiated by more TLC *poverty of content of speech* and *poverty of speech* (Andreasen, 1979b; Andreasen & Grove, 1986; Taylor, et al., 1994). Also, these patient groups are distinguishable by different patterns of relationships between FTD and cognitive functioning (Berenbaum, Kerns, Vernon, & Gomez, 2008) and by course of FTD (for review, see Roche, Creed, MacMahon, Brennan, & Clarke, 2014). Another limitation is that in the context of the research, we relied on self-report to screen for acute effects of alcohol and cannabis intoxication: We therefore cannot account for possible effects of intoxication on the findings. Along this line, we also acknowledge as a possibility

that other unmeasured constructs such as levels of autistic traits or developmental trauma may account for the observed relationships in our sample with elevated schizotypal traits.

Strengths of this study include: use of two clinical rating scales to index FTD; recruitment of a community-based sample of individuals with elevated schizotypal traits; the sample were young and free of confounds relating to antipsychotic medications and institutionalisation; and the false discovery rate was well-controlled, supporting reliability of the reported statistical relationships. This study also assessed psychosis-like traits using two scales relevant to this study (SPQ and BPQ), allowing stronger inferences about relationships between FTD and psychosis-like experiences in this sample.

Conclusions

Findings from this investigation support the conclusion that communicative disturbances are elevated in general-community samples with elevated schizotypal traits. Also, this study reports evidence indicating that the dimensional structure of communication disturbances in general-community samples with elevated schizotypal traits is generally consistent with schizophrenia research. An unexpected relationship emerged between increasing severity of verbosity-type FTD on the TLC and stronger IQ in our sample.

References

American Psychiatric Association. (1987). *Diagnostic and statistical manual of mental disorders (3rd ed., text rev.)*. Washington, DC: American Psychiatric Association.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (5th ed.)*. Washington, DC: American Psychiatric Association.

Andreasen, N. (1978). *The Scale for the Assessment of Thought, Language and Communication (TLC)*. Iowa City: The University of Iowa.

Andreasen, N. (1979a). Thought, language and communication disorders: I. Clinical assessments, definition of terms and evaluation of their reliability. *Archives of General Psychiatry, 36*(12), 1315-1321. doi: 10.1001/archpsyc.1979.01780120045006

Andreasen, N. (1979b). Thought, language and communication disorders: II. Diagnostic significance. *Archives of General Psychiatry, 36*(12), 1325-1330. doi: 10.1001/archpsyc.1979.01780120055007

Andreasen, N. (1986). *Scale for Assessment of Thought, Language, and Communication (TLC)*. Retrieved from http://psycnet.apa.

Andreasen, N. (1987). *Comprehensive Assessment of Symptoms and History*. Iowa City, IA: University of Iowa.

Andreasen, N., & Grove, W. M. (1986). Thought, language and communication in schizophrenia: Diagnosis and prognosis. *Schizophrenia Bulletin, 12*(3), 348-359. Retrieved from http://psycnet.apa.org

Andreou, C., Bozikas, V. P., Papouliakos, I., Kosmidis, M. H., Garyfallos, G., Kraravatos, A., & Nimatoudis, I. (2008). Factor structure of the Greek translation of the Scale for the Assessment of Thought, Language and Communication. *Australian and New Zealand Journal of Psychiatry, 2008*(42), 636-642. doi: 10.1080/00048670802119721

Angst, J., Adolfsson, R., Benazzi, F., Gamma, A., Hantouche, E., Meyer, T. D., . . . Scott, J. (2005). The HCL-32: towards a self-assessment tool for hypomanic symptoms in outpatients. *Journal of Affective Disorders, 88*(2), 217-233. doi: 10.1016/j.jad.2005.05.011

Asarnow, R. F., & MacCrimmon, D. J. (1982). Attention/information processing, neuropsychological functioning, and thought disorder during the acute and partial recovery phases of schizophrenia: a longitudinal study. *Psychiatry Research, 1*(3), 309-319. doi: 10.1016/0165-1781(82)90067-1

Australian Psychological Society. (2003). APS Code of Ethics Retrieved from https://www.psychology.org.au

Badcock, J. C., & Dragovic, M. (2006). Schizotypal personality in mature adults. *Personality and Individual Differences, 40*(1), 77-85.

Badoud, D., Billieux, J., Eliez, S., Imhof, A., Heller, P., Eytan, A., & Debbané, M. (2014). Covariance and specificity in adolescent schizotypal and borderline trait expression. *Early Intervention in Psychiatry*. doi: Advance online publication. doi: 10.1111/eip.12120

Balaratnasingam, S., & Janca, A. (2015). Normal personality, personality disorder and psychosis: current views and future perspectives. *Current Opinion in Psychiatry 28*(1), 30-34. doi: 10.1097/YCO.0000000000000124

Barch, D. M., & Berenbaum, H. (1996). Language production and thought disorder in schizophrenia. *Journal of Abnormal Psychology, 105*(1), 592-601. doi: 10.1037/0021-843X.105.1.81

Bazin, N., Lefrere, F., Passerieux, C., Sarfati, Y., & Hardy-Bayle, M. C. (2002). Formal thought disorders: French translation of the Thought, Language and Communication assessment scale. *Encephale, 28*(2), 109-119. Retrieved from http://europepmc.org

Bearden, C. E., Wu, K. N., Caplan, R., & Cannon, T. D. (2011). Thought disorder and communication deviance as predictors of outcome in youth at clinical high risk for psychosis. *Journal of the American Academy of Child and Adolescent Psychiatry, 50*(7), 669-680. doi: 10.1016/j.jaac.2011.03.021

Bell, N. L., Lassiter, K. S., Matthews, T. D., & Hutchinson, M. B. (2001). Comparison of the Peabody Picture Vocabulary Test-Third Edition and Wechsler Adult Intelligence Scale-Third Edition with university students. *Journal of Clinical Psychology, 57*(3), 417-422. doi: 10.1002/jclp.1024

Benjamini, Y., & Hochberg, Y. (1995). Controlling the false discovery rate: a practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society, 57*(1), 289-300. Retrieved from http://www.jstor.org

Berenbaum, H., Kerns, J. G., Vernon, L. L., & Gomez, J. J. (2008). Cognitive correlates of schizophrenia signs and symptoms: I. verbal communication disturbances. *Psychiatry Research, 159*(1-2), 147-156. doi: 10.1016/j.psychres.2007.08.016

Berenbaum, H., Oltmanns, T. F., & Gottesman, I. I. (1985). Formal thought disorder in schizophrenics and their twins. *Journal of Abnormal Psychology, 94*(1), 3-16. doi: 10.1037//0021-843X.94.1.3

Bleuler, E. (1911/1950). *Dementia praecox or the group of schizophrenias*. NY: International Universities Press.

Chanen, A. M., Jovev, M., McDougall, E., & Rawlings, D. (2008). Screening for borderline personality disorder in outpatient youth. *Journal of Personality Disorders, 22*(4), 353-364. doi: 10.1521/pedi.2008.22.4.353

Clara, I. P., Cox, B. J., & Enns, M. W. (2001). Confirmatory factor analysis of the Depression–Anxiety–Stress Scales in depressed and anxious patients. *Journal of Psychopathology and Behavioral Assessment, 23*(1), 61-67. doi: 10.1023/A:1011095624717

Coleman, M. J., Levy, D. L., Lenzenweger, M. F., & Holzman, P. S. (1996). Thought disorder, perceptual aberrations, and schizotypy. *Journal of Abnormal Psychology, 105*(3), 469-473. doi: 10.1037/0021-843X.105.3.469

Connolly, A. J., Cobb-Richardson, P., & Ball, S. A. (2008). Personality disorders in homeless drop-in center clients. *Journal of Personality Disorders, 22*(6), 573-588. doi: 10.1521/pedi.2008.22.6.573

Costello, A. B., & Osborne, J. W. (2005). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. *Practical Assessment Research and Evaluation, 10*(7). Retrieved from http://pareonline.net

Crawford, J., Cayley, C., Lovibond, P. F., Wilson, P. H., & Hartley, C. (2011). Percentile norms and accompanying interval estimates from an Australian general adult population sample for self-report mood scales (BAI, BDI, CRSD, CES-D, DASS, DASS-21, STAI-X, STAI-Y, SRDS, and SRAS). *Australian Psychologist, 46*(1), 3-14. doi: 10.1111/j.1742-9544.2010.00003.x

Cuesta, M. J., & Peralta, V. (1999). Thought disorder in schizophrenia. Testing models through confirmatory factor analysis. *European Archives of Psychiatry and Clinical Neuroscience, 249*(2), 55-61. doi: 10.1007/s004060050066

Cuesta, M. J., & Peralta, V. (2011). Testing the hypothesis that formal thought disorders are severe mood disorders. *Schizophrenia Bulletin, 37*(6), 1136-1146. doi: 10.1093/schbul/sbr092

Cuesta, M. J., Peralta, V., & De Leon, J. (1994). Schizophrenic syndromes associated with treatment response. *Progress in Neuro-Psychopharmacology and Biological Psychiatry, 18*(1), 87-99. doi: 10.1016/0278-5846(94)90026-4

Czermak, C., Lehofer, M., Gasser-Steiner, P., Ettinger, S., Lemonis, L., Rohrhofer, A. ..., & Liebmann, P. M. (2005). Test-retest reliability of a lifetime drug use questionnaire. *Addictive Behaviours, 30*(2), 361-368. doi: 10.1016/j.addbeh.2004.05.005

Davis, G. C., Simpsom, D. M., Foster, D., Arison, Z., & Post, M. (1986). Reliability of Andreasen's thought, language, and communications disorder scale. *Hillside Journal of Clinical Psychiatry, 8*(1), 25-33. Retrieved from http://psycnet.apa.org

Demjaha, A., Valmaggia, L., Stahl, D., Byrne, M., & McGuire, P. (2012). Disorganization/cognitive and negative symptom dimensions in the at-risk mental state predict subsequent transition to psychosis. *Schizophrenia Bulletin, 38*(2), 351-359. doi: 10.1093/schbul/sbq088

DeVylder, J. E., Muchomba, F. M., Gill, K. E., Ben-David, S., Walder, D. J., Malaspina, D., & Corcoran, C. M. (2014). Symptom trajectories and psychosis onset in a clinical high-risk cohort: The relevance of subthreshold thought disorder. *Schizophrenia Research, 159*(2), 278-283. doi: 10.1016/j.schres.2014.08.008

Docherty, N. M. (1996). Manual for the Communication Disturbances Index (CDI). Kent, Ohio: Kent State University.

Docherty, N. M., & Gordinier, S. W. (1999). Immediate memory, attention and communication disturbances in schizophrenia patients and their relatives. *Psychological Medicine, 29*(1), 189-197. doi: 10.1017/S0033291798007843

Dugbartey, A. T., Sanchez, P. N., Rosenbaum, J. G., Mahurin, R. K., Davis, J. M., & Townes, B. D. (1999). WAIS-III Matrix Reasoning test performance in a mixed clinical sample. *The Clinical Neuropsychologist, 13*(4), 396-404. doi: 10.1076/1385-4046(199911)13:04;1-Y;FT396

Dunn, L. M., & Dunn, D. M. (2007). Peabody Picture Vocabulary Test- Fourth Edition. Minneapolis, MN: Pearson Education, Inc.

Ettinger, U., Meyhöfer, I., Steffens, M., Wagner, M., & Koutsouleris, N. (2014). Genetics, cognition, and neurobiology of schizotypal personality: a review of the overlap with schizophrenia. *Frontiers in Psychiatry*. doi: Advance online publication. doi: 10.3389/fpsyt.2014.00018

Faul, F., Erdfelder, E., Buchner, A., & Lang, A. -G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods, 41*(4), 1149-1160. Retrieved from http://www.gpower.hhu.de

Fervaha, G., & Remington, G. (2013). Neuroimaging findings in schizotypal personality disorder: A systematic review. *Progress in Neuro-Psychopharmacology and Biological Psychiatry, 43*, 96-107. doi: 10.1016/j.pnpbp.2012.11.014

First, M. B., Spitzer, R. L. , M., Gibbon, & Williams, J. B. W. (Eds.). (2002). *Structured Clinical Interview for DSM-IV-TR Axis I Disorders, Research Version, Non-patient Edition. (SCID-I/NP)*. New York: Biometrics Research, New York State Psychiatric Institute.

First, M. B., Spitzer, R. L., Gibbon, M., Williams, J. B. W., & Benjamin, L. (1994). *Structured Clinical Interviews for DSM-IV Axis II Personality Disorders (SCID-II, Version 2.0)*. New York: Biometrics Research, New York State Psychiatric Institute.

Fonseca-Pedrero, E., Lemos-Giráldez, S., Paino, M., Sierra-Baigrie, S., & Muñiz, J. (2012). Relationship between schizotypal and borderline traits in college students. *The Spanish Journal of Psychology, 15*(1), 306-314. doi: 10.5209/rev_SJOP.2012.v15.n1.37337

Ford, T., Goodman, R., & Meltzer, H. (2003). The British Child and Adolescent Mental Health Survey 1999: The prevalence of DSM-IV disorders. *Journal of the American Academy of Child and Adolescent Psychiatry, 42*(10), 1203-1211. doi: 10.1097/00004583-200310000-00011

Fulford, D., Feldman, G., Tabak, B. A., McGillicuddy, M., & Johnson, S. L. (2013). Positive affect enhances the association of hypomanic personality and cognitive flexibility. *International Journal of Cognitive Therapy, 6*(1), 1-16. doi: 10.1521/ijct.2013.6.1.1

Furnham, A., Batey, M., Anand, K., & Manfield, J. (2008). Personality, hypomania, intelligence and creativity. *Personality and Individual Differences*, *44*(5), 1060–1069. doi: 10.1016/j.paid.2007.10.035

Gooding, D. C., Coleman, M., Roberts, S. A., Shenton, M. E., Levy, D. L., & Erlenmeyer-Kimling, L. (2010). Thought disorder in offspring of schizophrenic parents: findings from the New York High-Risk Project. *Schizophrenia Bulletin, 38*(2), 263-271. doi: 10.1093/schbul/sbq061

Gooding, D. C., Ott, S. L., Roberts, S. A., & Erlenmeyer-Kimling, L. (2013). Thought disorder in mid-childhood as a predictor of adulthood diagnostic outcome: findings

from the New York High-Risk Project. *Psychological Medicine, 43*(05), 1003-1012. doi: 10.1017/S0033291712001791

Gossop, M., Darke, S., P., Griffiths, Hando, J., Powis, B., Hall, W., & Strang, J. (1995). The Severity of Dependence Scale (SDS): psychometric properties of the SDS in English and Australian samples of heroin, cocaine and amphetamine users. *Addiction, 90*(5), 607-614. doi: 10.1046/j.1360-0443.1995.9056072.x

Gras, A., Amad, A., Thomas, P., & Jardri, R. (2014). Hallucinations and borderline personality disorder: a review. *Encephale, 40*(6), 431-438. doi: 10.1016/j.encep.2014.07.002

Harvey, P. D., Earle-Boyer, E. A., & Levinson, J. C. (1988). Cognitive deficits and thought disorder: a retest study. *Schizophrenia Bulletin, 14*(1), 57-66. Retrieved from http://europepmc.org

Harvey, P. D., Earle-Boyer, E. A., & Wielgus, M. S. (1984). The consistency of thought disorder in mania and schizophrenia. An assessment of acute psychotics. *Journal of Nervous and Mental Disease, 172*(8), 458-463. doi: 10.1097/00005053-198408000-00003

Harvey, P. D., Lenzenweger, M. F., Keefe, R. S. E., Pogge, D. L., Serper, M. R., & Mohs, R. C. (1992). Empirical assessment of the factorial structure of clinical symptoms in schizophrenic patients: formal thought disorder. *Psychiatry Research, 44*(2), 141-151. doi: 10.1016/0165-1781(92)90048-8

Harvey, P. D., & Serper, M. R. (1990). Linguistic and cognitive failures in schizophrenia. A multivariate analysis. *Journal of Nervous and Mental Disease, 178*(8), 487-493. doi: 10.1097/00005053-199017880-00003

Henry, J. D., & Crawford, J. R. (2005). The short-form version of the Depression Anxiety Stress Scales (DASS-21): construct validity and normative data in a large non-clinical sample. *British Journal of Clinical Psychology, 44*(2), 227-239. doi: 10.1348/014466505X29657

Holtmann, M., Pörtner, F., Duketis, E., Flechtner, H., Angst, J., & Lehmkuhl, G. (2009). Validation of the Hypomania Checklist (HCL-32) in a nonclinical sample of German adolescents. *Journal of Adolescence, 32*(5), 1075-1088. doi: 10.1016/j.adolescence.2009.03.004

Kerns, J. G., & Becker, T. M. (2008). Communication disturbances, working memory, and emotion in people with elevated disorganized schizotypy. *Schizophrenia Research, 100*(1-3), 172-180. doi: 10.1016/j.schres.2007.11.005

Kerns, J. G., & Berenbaum, H. (2002). Cognitive impairments associated with formal thought disorder in people with schizophrenia. *Journal of Abnormal Psychology*, *111*(2), 211-224. doi: 10.1037/0021-843X.111.2.211

Kranzler, H. R., Kadden, R. M., Babor, T. F., Tennen, H., & Rounsaville, B. J. (1996). Validity of the SCID in substance abuse patients. *Addiction, 91*(6), 859-868. doi: 10.1046/j.1360-0443.1996.91685911.x

Kwapil, T. R., Miller, M. B., Zinser, M. C., Chapman, L. J., Chapman, J., & Eckblad, M. (2000). A longitudinal study of high scorers on the Hypomanic Personality Scale. *Journal of Abnormal Psychology, 109*(2), 222-226. doi: 10.1037/0021-843x.109.2.222

Larrabee, G. J. (2012). Performance validity and symptom validity in neuropsychological assessment. *Journal of the International Neuropsychological Society, 18*(4), 1-7. doi: 10.1017/S1355617712000240

Lawrinson, P., Copeland, J., Gerber, S., & Gilmour, S. (2007). Determining a cut-off on the Severity of Dependence Scale (SDS) for alcohol dependence. *Addictive Behaviors, 32*(7), 1474-1479. doi: 10.1016/j.addbeh.2006.09.005

Lenhard, W., & Lenhard, A. (2015). Calculation of effect sizes. Retrieved from http://www.psychometrica.de

Lentz, V., Robinson, J., & Bolton, J. M. (2010). Childhood adversity, mental disorder comorbidity, and suicidal behavior in schizotypal personality disorder. *The Journal of Nervous and Mental Disease*, *198*(11), 795-801. doi: 10.1097/NMD.0b013e3181f9804c

Liddle, P. F., Ngan, E. T. C., Caissie, S. L., Anderson, C. M., Bates, A. T., Quested, D. J., . . . Weg, R. (2002). Thought and Language Index: an instrument for assessing thought and language in schizophrenia. *British Journal of Psychiatry*, *181*(4), 326-330. doi: 10.1192/bjp.181.4.326

Lobbestael, J., Leurgans, M., & Arntz, A. (2010). Inter-rater reliability of the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID I) and Axis II Disorders (SCID II). *Clinical Psychology and Psychotherapy*, *18*(1), 75-79. doi: 10.1002/cpp.693

Lovibond, S. H., & Lovibond, P. F. (1995). *Manual for the Depression Anxiety Stress Scales*. Sydney: Psychology Foundation.

Macare, C., Bates, T. C., Heath, A. C., Martin, N. G., & Ettinger, U. (2012). Substantial genetic overlap between schizotypy and neuroticism: a twin study. *Behavior genetics, 42*(5), 732-742. doi: 10.1007/s10519-012-9558-6

Martin, G., Copeland, J., Gates, P., & Gilmore, S. (2006). The Severity of Dependence Scale (SDS) in an adolescent population of cannabis users: Reliability, validity and

diagnostic cut-off. *Drug and Alcohol Dependence, 83*(1), 90-93. doi: 10.1016/j.drugalcdep.2005.10.014

Mazumdar, P. K., Chaturvedi, S. K., Sinha, V., & Gopinath, P. S. (1991). Scale for Assessment of Thought, Language and Communication in psychotic in-patients. *Psychopathology, 24*(4), 199-202. doi: 10.1159/000284714

McKenna, P. J., & Oh, T. M. (2005). *Schizophrenic speech: Making sense of bathroots and ponds that fall in doorways*. Cambridge: Cambridge University Press.

Miers, T., & Raulin, M. L. (1987). The Cognitive Slippage Scale. In K. Corcoran & J. Fischer (Eds.), *Measures for clinical practice: a source book*. New York: Free Press.

Miller, E. N., & Chapman, L. J. (1983). Continued word association in hypothetically psychosis-prone college students. *Journal of Abnormal Psychology, 92*(4), 468-478. doi: 10.1037/0021-843X.92.4.468

Minor, K. S., & Cohen, A. S. (2010). Affective reactivity of speech disturbances in schizotypy. *Journal of Psychiatric Research, 44*(2), 99-105. doi: 10.1016/j.jpsychires.2009.06.005

Murray, H. A. (1943). *Thematic Apperception Test manual*.

Nagels, A., Stratmann, M., Ghazi, S., Schales, C., Frauenheim, M., Turner, L., . . . Kircher, T. T. (2013). The German translation and validation of the Scale for the Assessment of Thought, Language and Communication: A factor analytic study. *Psychopathology, 46*(6), 390-395. doi: 10.1159/000345359

Nelson, M. T., Seal, M. L., Pantelis, C., & Phillips, L. J. (2013). Evidence of a dimensional relationship between schizotypy and schizophrenia: A systematic review. *Neuroscience & Biobehavioral Reviews, 37*(3), 317-327. doi: 10.1016/j.neubiorev.2013.01.004

Ott, S. L., Roberts, S., Rock, D., Allen, J., & Erlenmeyer-Kimling, L. (2002). Positive and negative thought disorder and psychopathology in childhood among subjects with adulthood schizophrenia. *Schizophrenia Research, 58*(2-3), 231-239. doi: 10.1016/S0920-9964(01)00339-5

Peralta, V., Cuesta, M. J., & De Leon, J. (1992). Formal thought disorder in schizophrenia: a factor analytic study. *Comprehensive Psychiatry, 33*(2), 105-110. doi: 10.1016/0010-440X(92)90005-B

Peterson, R. A. (2001). On the use of college students in social science research: Insights from a second-order meta-analysis. *Journal of Consumer Research, 28*(3), 450-461. doi: 10.1086/323732

Poreh, A. M., Rawlings, D., Claridge, G., Freeman, J. L., Faulkner, C., & Shelton, C. (2006). The BPQ: A Scale for the Assessment of Borderline Personality Based on DSM-IV Criteria. *Journal of Personality Disorders*, *20*(3), 247-260. doi: 10.1521/pedi.2006.20.3.247

Raine, A. (1991). The SPQ: A scale for the assessment of schizotypal personality based on DSM-III-R criteria. *Schizophrenia Bulletin, 17*(4), 556-564. Retrieved from http://europepmc.org

Raine, A., Reynolds, C., Lencz, T., Scerbo, A., Triphon, N., & Kim, D. (1994). Cognitive-perceptual, interpersonal, and disorganized features of schizotypal personality. *Schizophrenia Bulletin*, *20*(1), 191-201. Retrieved from http://europepmc.org

Roche, E., Creed, L., MacMahon, D., Brennan, D., & Clarke, M. (2014). The epidemiology and associated phenomenology of formal thought disorder: A systematic review. *Schizophrenia Bulletin*. doi: Advance online publication. doi: 10.1093/schbul/sbu129

Rohling, M. L., & Boone, K. B. (2007). Future directions in effort assessment. In K. B. Boone (Ed.), *Assessment of feigned cognitive impairment* (pp. 453-469). London: The Guilford Press.

Salavera, C., Puyuelo, M, Antoñanzas, J. L., & Teruel, P. (2013). Semantics, pragmatics, and formal thought disorders in people with schizophrenia. *Neuropsychiatric Disease and Treatment, 9*, 177-183. doi: 10.2147/NDT.S38676

Sans-Sansa, B., McKenna, P. J., Canales-Rodriguez, E. J., Ortiz-Gil, J., Lopez-Araquistain, L. L., Sarro, S., . . . Pomarol-Clotet, E. (2013). Association of formal thought disorder in schizophrenia with structural brain abnormalities in language-related cortical regions. *Schizophrenia Research, 146*(1-3), 308-313. doi: 10.1016/j.schres.2013.02.032

Stevens, J. P. (2009). *Applied multivariate statistics for the Social Sciences* (5th ed.). New York, NY: Routledge.

Stringaris, A., Castellanos-Ryan, N., Banaschewski, T., Barker, G. J., Bokde, A. L., Bromberg, U., . . . Conrod, P. (2014). Dimensions of manic symptoms in youth: psychosocial impairment and cognitive performance in the IMAGEN sample. *Journal of Child Psychology and Psychiatry, and Allied Disciplines, 55*(12), 1380-1389. doi: 10.1111/jcpp.12255

Taylor, M. A., Reed, R., & Berenbaum, S. (1994). Patterns of speech disorders in schizophrenia and mania. *Journal of Nervous and Mental Disease, 182*(6), 319-326. doi: 10.1097/00005053-199406000-00002

Tombaugh, T. N. (1996). Test of Memory Malingering (TOMM). New York, NY: Multi-Health Systems, Inc.

Uitenbroek, D. G. (1997). SISA Binomial. Retrieved from http://www.quantitativeskills.com

van Os, J., Linscott, R. J., Myin-Germeys, L., Delespaul, P., & Krabbendam, L. (2009). A systematic review and meta-analysis of the psychosis continuum: evidence for a psychosis proneness-persistence-impairment model of psychotic disorder. *Psychological Medicine, 39*(2), 179-195. doi: 10.1017/S0033291708003814

Velikonja, T., Fisher, H. L., Mason, O., & Johnson, S. (2015). Childhood trauma and schizotypy: a systematic literature review. *Psychological Medicine, 45*(5), 947-963. doi: 10.1017/S0033291714002086

Walker, E., & Harvey, P. D. (1986). Positive and negative symptoms in schizophrenia: attentional performance correlates. *Psychopathology, 19*(6), 294-302. doi: 10.1159/000284452

Wechsler, D. (1997). *Wechsler Adult Intelligence Scale-Third Edition*. San Antonio, TX: Psychological Corporation.

Wechsler, D. (2008). *Wechsler Adult Intelligence Scale-Fourth Edition: Technical and interpretive manual*. San Antonio, TX: Pearson.

Weinstein, S., McKay, R., & Ngan, E. T. (2008). Positive schizotypy is not associated with speech abnormality. *Early Intervention in Psychiatry*, *2*(2), 98-102. doi: 10.1111/j.1751-7893.2008.00064.x

Paper Two

The Dimensional Nature of "Formal Thought Disorder" in HomelessYoung Adults with Elevated Schizotypal Traits: Cognitive Correlates

Candidate's contribution: The candidate played a major role in organising the protocols and designing this study. In addition, they conducted the literature search, collected and coded all data, performed all initial analyses, and acted as senior author.

Abstract

Background and Aims: Evidence supporting the dimensional nature of communication disturbances in patients with schizophrenia, or *formal thought disorder* (FTD), includes research reporting FTD dimensions distinguished by different patterns of cognitive dysfunction. However, inconsistency in these findings may relate to patient-related confounds. The continuum approach to schizophrenia research may provide a means to address this, by investigating these relationships in non-clinical samples with attenuated schizophrenia-like traits, or *schizotypal* traits. To our knowledge, no study has done this.

Method. We examined relationships between FTD and cognitive dimensions in homeless young adults (N = 91) with elevated schizotypal traits on the Schizotypal Personality Questionnaire who were recruited from homeless services. FTD dimension scores were derived following principal components analysis of the Scale for the Assessment of Thought, Language and Communication (TLC dimensions: Disorganisation, Verbosity, Emptiness) and the Thought and Language Index (TLI dimensions: Negative, Idiosyncratic), as reported in Paper 1. The sample completed a comprehensive neuropsychological battery.

Results: TLI Negative was best-predicted by a combination of set shift and higher-order reasoning impairment; and TLC Disorganisation was best-predicted by higher-order reasoning and language/semantic dysfunction. Less strongly, TLI Idiosyncratic and TLC Emptiness were predicted by language/semantic dysfunction and impaired higher-order reasoning ability, respectively. These TLC/TLI dimensions were not clearly differentiated from each other by their cognitive relationships; but they were differentiated from TLC Verbosity, which was related to *stronger* cognitive functioning (verbal generative ability and language/semantic functioning).

Conclusion: Findings indicate that higher-order reasoning, executive function (set shift and generative ability), and language/semantic functioning are the primary drivers of FTD in general-community persons with elevated schizotypal traits.

Keywords: formal thought disorder, neuropsychological, cognitive, schizophrenia, schizotypy, the Scale for the Assessment of Thought, Language and Communication, Thought and Language Index

The Dimensional Nature of "Formal Thought Disorder" in Homeless Young Adults with Elevated Schizotypal Traits: Cognitive Correlates

Disturbances of the form of speech, such as changing the topic of conversation disjointedly, incoherence, or using words in an unusual manner are characteristic of schizophrenia (American Psychiatric Association, 2013); and collectively these are referred to as *formal thought disorder* (FTD). The term originates from traditional psychiatry, which sought to distinguish abnormalities of *content* of thought (e.g., delusions) from peculiarities in the *form* of thought, as revealed through speech. Its aetiology remains elusive; however, neuropsychological evidence consistently associates FTD with higher-order executive dysfunction and impaired processing of semantic information in patients with schizophrenia (Kerns & Berenbaum, 2002). In addition, some research links dysfunction to other domains of cognition with FTD in patients with schizophrenia, including slowed information processing (Stirling, Hellewell, Blakeley, & Deakin, 2006), impaired vigilance/sustained attention (Harvey & Pedley, 1989), reduced attention span, memory dysfunction, reduced language abilities, impaired higher-order reasoning (Berenbaum, Kerns, Vernon, & Gomez, 2008), and source monitoring dysfunction (Barch & Berenbaum, 1996; Harvey, 1985; Harvey, Earle-Boyer, & Levinson, 1988). Consequent to this evidence linking FTD with cognitive deficits, there is a focus on developing cognitive models to explain FTD and inform psychological intervention. A greater understanding of the aetiology of FTD may also assist to identify factors related to progression to psychosis. Supporting this view, recent evidence indicates FTD as among the most predictive indicators for transition to psychosis in individuals at-risk for psychosis (Bearden, Wu, Caplan, & Cannon, 2011; Demjaha, Valmaggia, Stahl, Byrne, & McGuire, 2012; DeVylder et al., 2014; Wilcox, Briones, Quadri, & Tsuang, 2014). Also of note, FTD also occurs in mania and other conditions; and may be evident in persons without psychiatric illness, suggesting that it may be a continuum phenomenon (for discussions, see

Andreasen, 1979b; van Os, Linscott, Myin-Germeys, Delespaul, & Krabbendam, 2009). In support of a continuum approach to studying FTD, we have previously demonstrated elevated levels of FTD in a sample of homeless young adults with relatively high levels of attenuated schizophrenia-like traits (i.e., *schizotypal traits*; Paper 1); and the underlying dimensional structure of FTD in this sample generally resembled the structure of FTD previously reported in patients with schizophrenia. Whether neuropsychological investigation will reveal that FTD also associates with cognitive function in general-community samples with elevated schizotypal traits remains unknown; and is the focus of the present investigation.

FTD is usually regarded as having both *positive FTD* (PFTD) and *negative FTD* (NFTD) dimensions in patients with schizophrenia. As mentioned above, PFTD refers to abnormalities of unusual presence of atypical forms of speech, such as responding obliquely or incoherently. It is typical of acute schizophrenia and mania; and associated with intact or excessive affect (Andreasen, 1979b). NFTD usually consists of reduced speech output and markedly vague speech which is empty of meaningful; and occurs most often in chronic schizophrenia where flat affect predominates (Andreasen). The relative independence of these dimensions is supported clinically and experimentally (for review, see Cuesta & Peralta, 1999). For example, clinical findings indicate they are differentiated by NFTD conferring worse prognosis and functioning than PFTD (Andreasen & Grove, 1986). PFTD and NFTD are also differentiated by their different relationships with different diagnoses (Andreasen; Andreasen & Grove; Harvey, Earle-Boyer, & Wielgus, 1984), and by different associations with other conceptually-related symptoms in schizophrenia (DSM-V, American Psychiatric Association, 2013; Walker & Harvey, 1986). Experimentally, PFTD and NFTD have been distinguished by different patterns of cognitive dysfunction (Berenbaum, et al., 2008). Preliminary evidence also describes different patterns of cortical volume loss in PFTD and NFTD: PFTD has been associated with grey matter reduction to the left superior temporal

cortex and left frontal inferior operculum/pars triangularis, regions associated with language functioning, suggesting that PFTD relates to a breakdown of basic language processes. Whereas NFTD, in particular *poverty of content of speech* has been linked to volume reduction to the ventromedial frontal and orbitofrontal cortex bilaterally, regions that may contribute to "speech output and content" (Sans-Sansa et al., 2013).

Despite the traditional focus on positive and negative dimensions of FTD, evidence indicates that FTD's dimensional structure may be more nuanced than a simple NFTD-PFTD dichotomy. For example, variable reduction techniques, such as principal components analysis, describe three generally reliable dimensions using the Scale for the Assessment of Thought, Language and Communication (TLC, Andreasen, 1978), usually labelled as Disorganisation, Emptiness/Negative, and either Verbosity or Linguistic Control in patients with schizophrenia and other psychotic disorders (Andreasen, 1979b; Andreasen & Grove, 1986; Andreou et al., 2008; Bazin, Lefrere, Passerieux, Sarfati, & Hardy-Bayle, 2002; Berenbaum, Oltmanns, & Gottesman, 1985; Cuesta & Peralta, 1999, 2011; Harvey et al., 1992; Nagels et al., 2013; Ott, Roberts, Rock, Allen, & Erlenmeyer-Kimling, 2002; Peralta, Cuesta, & De Leon, 1992; Taylor, Reed, & Berenbaum, 1994). Liddle et al. (2002) reported a similar three-component solution in a sample with schizophrenia and other psychotic disorders, using the Thought and Language Index (TLI, Liddle, et al.), which was developed to index more subtle FTD, such as may occur in non-clinical samples.

Neuropsychological evidence consistently associates executive dysfunction and impaired processing of semantic information with FTD in samples with schizophrenia; and some evidence indicates a possible link between more subtle impairment of language production and FTD (Kerns & Berenbaum, 2002). Some variability of findings is likely to reflect patient-related status and sample heterogeneity. Also of concern, findings from mixed diagnostic samples may generalize poorly to schizophrenia, as some psychotic illness (e.g.,

mania and schizophrenia) may be distinguished by different FTD subtypes (Andreasen, 1979b; Andreasen & Grove, 1986; Harvey, et al., 1988; Harvey, et al., 1984; Walker & Harvey, 1986). PFTD and NFTD have also been distinguished by different patterns of cognitive dysfunction (Berenbaum, et al., 2008) and by different neural underpinnings. For example, preliminary evidence suggests different patterns of cortical volume loss in PFTD and NFTD (Sans-Sansa, et al., 2013).

The *continuum approach* is a research method used to examine schizophrenia symptomatology in non-clinical samples with elevated schizotypal traits (for discussion, see Persons, 1986); and is therefore without patient-related confounds. Schizotypal traits are commonly indexed using self-report questionnaires, such as the Schizotypal Personality Questionnaire (SPQ; Raine, 1991). The continuum approach is based on the hypothesis that schizophrenia's symptomatology lies at the extreme end-point of a psychosis continuum that is anchored by schizotypal traits at the sub-clinical end (for discussion, see van Os, et al., 2009). Empirical support for the approach includes multidisciplinary evidence of neurobiological, cognitive, psychopharmacological, genetic, perceptual, social, environmental, symptom structure, and motor similarities between schizophrenia and non-clinical schizotypy (for review, see Ettinger, Meyhöfer, Steffens, Wagner, & Koutsouleris, 2014; Nelson, Seal, Pantelis, & Phillips, 2013).

The suitability of the continuum approach to FTD research using general-community samples is uncertain; however, some evidence links elevated schizotypal traits with objectively-rated communication disturbance in undergraduate samples (Coleman, Levy, Lenzenweger, & Holzman, 1996; Minor & Cohen, 2010) and with self-reported communication disturbance (Gooding, Tallent, & Hegyi, 2001), but not all studies report a relationship between schizotypal traits and communication disturbance in undergraduate samples (Weinstein, McKay, & Ngan, 2008). Stress appears to disorganize speech, but this

relationship is not specific to schizotypy: It has been reported in samples with elevated schizotypal traits (Kerns & Becker, 2008), and samples with relatively low levels of schizotypal traits (Minor & Cohen). However, stress-induced communication disturbances may relate to the cognitive disturbances that associate with schizotypy: In undergraduate samples with elevated schizotypal traits (but not in those with low levels of such traits), greater severity of stress-induced communication disturbance has been related to poorer working-memory performance (Kerns & Becker, 2008) and greater atypical sequencing of category items (Minor, Cohen, Weber, & Brown, 2011). Preliminary evidence also links raised communication disturbances with aberrant visual context processing in undergraduates with elevated schizotypal traits (Uhlhaas, Silverstein, Phillips, & Lovell, 2004).

Inconsistency of findings from continuum studies of FTD in undergraduate samples may reflect limited variability of communication disturbances in these highly-educated undergraduate samples, who have been shown to be consistently less variable on many constructs of interest in psychological research (Peterson, 2001; see also Paper 1 for discussion). A related concern is the substantial issue of whether findings from high-functioning undergraduates with psychometrically-elevated schizotypal traits generalize to persons with schizotypal traits with poorer functioning; and to the schizophrenia-spectrum more broadly (for discussion, see all Lenzenweger, 2010; Minor, et al., 2011; Neill, 2014; Raine & Lencz, 1995). Similarly, some evidence suggests that people have difficulty rating their own levels of communication disturbance: Docherty (1993) reported no correspondence between objectively-rated FTD and self-rated "odd communication" in the parents of patients with schizophrenia. We also found no relationship between objectively-rated FTD and self-reported *odd speech* on the SPQ in the current sample with elevated schizotypal traits (see Paper 1).

Recently (see Paper 1), we reported a high prevalence of elevated schizotypal traits in a community sample of young adults attending homeless services using psychometric and interview approaches. We chose to recruit our sample from these locations rather than university settings because we felt that participants recruited from homeless settings may be more representative of the psychosocial adversity and disadvantage (e.g., homelessness, unemployment, substance use, and early trauma, household dysfunction and distress) that have been associated with schizotypal traits in the general community (Afifi et al., 2011; Lentz, Robinson, & Bolton, 2010; Velikonja, Fisher, Mason, & Johnson, 2015) and more representative of the early childhood trauma and adversity that have been linked with schizophrenia (Bendall, Jackson, Hulbert, & McGorry, 2008; Read, Fosse, Moskowitz, & Perry, 2014; Varese et al., 2012). Our sample was also characterized by psychometrically-elevated borderline personality disorder traits and psychological distress, a high prevalence of diagnosed substance abuse and dependence, relatively low educational attainment, and significant psychosocial adversity, as they were recruited from services for homeless youth: Yet, the sample was of average-range IQ and free of DSM-V Axis I psychotic illness. As well, some evidence suggests that among the persons who use such services, there is a high prevalence of individuals who meet criteria for Schizotypal Personality Disorder (SPD), and are otherwise free of DSM-V Axis-I psychotic illness (Connolly, Cobb-Richardson, & Ball, 2008). Pertinent to this enquiry, the sample also evidenced elevated levels of objectively-rated FTD assessed using both the TLC and TLI. PCA of both FTD scales showed underlying symptom dimensions similar to those reported using these scales in samples with schizophrenia; and TLC Disorganisation and TLC Emptiness dimensions were associated with self-reported psychosis-like experiences on the measures of schizotypal and borderline traits.

Aims and Hypothesis

To our knowledge, no research to date has used the continuum approach to investigate the cognitive profile of objectively-rated FTD, in particular, those profiles associated with different dimensions of FTD. As our main aim, we address this absence by examining relationships between dimensions of cognitive functioning and FTD in homeless young persons with psychometrically-elevated schizotypal traits. Our sample is the same as reported in Paper 1. We had originally recruited these young adults to contribute to the evidence investigating FTD in samples at-risk for psychosis, as this cohort with its high levels of psychosocial adversity may have particular relevance to understanding the pathogenesis of schizophrenia (Kyriakopoulos and Frangou, 2007). As reported in more detail in Paper 1, FTD was indexed using two rating scales (the TLC and TLI) and PCA revealed different dimensions of FTD in this sample. Our aim in this paper is to investigate the relationships between cognitive functioning and these different FTD dimensions, similar to Berenbaum et al. (2008); and we undertook their recommendation to explore fine-grained distinctions within cognitive functioning by examining subdomains of attention, semantic processing, and executive function which have been reported to be relevant in the clinical FTD literature. FTD dimension scores were those derived following PCA for this sample, as reported in our previous paper (Paper 1). These included three dimensions of FTD revealed using the TLC: Disorganisation, Verbosity and Emptiness; and two dimensions revealed using the TLI: Negative and Idiosyncratic. We had one general hypothesis: That significant relationships exist between dimensions cognitive functioning and FTD in this sample. We had no particular expectations about which cognitive dimensions might relate more specifically to particular dimensions of FTD.

Method

Sample and Participant Selection

A total of 126 potential participants were recruited at two large youth welfare services located in Sydney and Melbourne, Australia. Eligibility criteria included: age range 16-25 years, English as first language, and self-reported alcohol and drug abstinence for the previous 24 hours. Full details of the screening procedure are provided in Paper 1. In brief, exclusion criteria included low verbal or performance IQ assessed respectively using the Peabody Picture Vocabulary Test-IV (PPVT-IV, Dunn & Dunn, 2007) and WAIS-IV Matrix Reasoning (Wechsler, 2008), and inadequate effort on task assessment assessed using the Test of Memory Malingering (Tombaugh, 1996) and Forced-choice recognition from the California Verbal Learning Test-Second Edition (CVLT-II, Delis, Kramer, Kaplan, & Ober, 2000). Exclusion criteria also included DSM-V Axis I psychotic illness, central nervous system disease, developmental disorder, or history of head injury with loss of consciousness exceeding one hour. Twenty-one were thus excluded (reported in detail in Paper 1) and 13 eligible participants did not complete the testing session; leaving data from 92 participants for initial analysis. Participants were reimbursed $60 in the form of gift cards. They were provided written informed consent and treated in accordance with the Australian Psychological Society's *Code of Ethics* (2003). Macquarie University's Human Research Ethics Committee approved the study (5201001263).

Materials

In addition to the cognitive screening battery described briefly above, all participants underwent a clinical interview and completed personality measures (see Paper 1 again for full details), as follows:

Clinical interviews and inventories. *The Lifetime Drug Use* (LDU, Czermak et al., 2005) is a semi-structured interview approach to estimating total lifetime consumption of a

substance. The measures of interest were lifetime ounces of cannabis and standard drinks consumed: *LDU-C* and *LDU-A*, respectively.

The *Severity of Dependence Scale* (SDS, Gossop et al., 1995) is a 5-item self-report questionnaire that indexes psychological dependency for substances over the previous month. The variables of interest were total scores for cannabis and alcohol versions: *SDS-C* and *SDS-A*, respectively (range = 0 - 15).

The *Depression Anxiety Stress Scales-21 item version* (DASS-21) is a short form of the DASS (Lovibond & Lovibond, 1995) self-report scale that provides a dimensional measurement of depression, anxiety and stress symptoms. The measures of interest were total and subscale scores: *DASS-Total* (range 0-63), and *DASS-Depression, -Anxiety* and *-Stress*, respectively (subscales range 0 - 21).

Personality measures. Schizotypal traits were assessed using the SPQ's (Raine, 1991) 74 *yes/no* questions which index nine schizotypal traits that correspond to DSM-III-R SPD criteria (American Psychiatric Association, 1987): *SPQ-Total* (range 0 – 74).

The *Borderline Personality Questionnaire* (BPQ, Poreh et al., 2006) was also used to assess borderline traits. Its 80 *true/false* questions provide a dimensional index that corresponds to DSM-IV Borderline Personality Disorder criteria (BPD, American Psychiatric Association, 1987): *BPQ-Total* (range 0 – 80). Its subscales are *impulsivity, affective instability, abandonment, unstable relationships, self-image, self-mutilation, emptiness, intense anger,* and *quasi-psychotic states*.

Thought disorder scales. As outlined in detail in Paper 1, FTD was assessed using the TLC and TLI in accord with the guidelines in order to then use principle components analyses (PCA) to identify distinct dimensions of thought disorder in this sample. In brief, the TLC includes ratings for 18 subtypes of FTD derived from an interview using semi-structured probes about a participant's current life and attitudes for approximately 45-minutes. The TLC is

highly reliable (Andreasen, 1978, 1979a, 1979b; Andreasen & Grove, 1986; Davis, Simpsom, Foster, Arison, & Post, 1986).

The TLI (Liddle, et al., 2002) was developed to index eight types of subtle aberrations of speech derived from a speech sample in which participants describe eight images from the Thematic Apperception Test (Murray, 1943) for one minute each. It has demonstrated reliability (*ICC* for individual items ranged from .60 to .93) and convergent validity (Liddle, et al.).

Based on the results of Paper 1, the current study uses PCA-derived scores for three TLC dimensions, labelled Disorganisation, Verbosity, and Emptiness, and two TLI dimensions, labelled Negative and Idiosyncratic.

Cognitive measures. We used a relatively comprehensive neuropsychological test battery to index a broad range of cognitive functions, as FTD has been linked with a wide range of cognitive deficits in patients with schizophrenia (see Introduction). Tests were selected according to their standing in neuropsychological research and practice, psychometric properties, and demonstrated sensitivity in clinical FTD research. The battery included eight tests from the Cambridge Neuropsychological Test Automated Battery (CANTAB) eclipse version 3.0 schizophrenia battery (Sahakian & Owen, 1992). These were run on a Motion™ touch-screen tablet PC operating Microsoft Windows 7: A 2-button press pad from the test distributor was used for some tests. We felt that CANTAB's computer-based game-like format may be engaging for our young sample (Levaux et al., 2007) and reduce interaction, which might be advantageous, as our sample may experience social or communication difficulty (Luciana, 2003). CANTAB has strong empirical and theoretical support (for review, see Barnett et al., 2010). Neural systems contributing to performance, psychometric properties and related research have been reviewed (Barch, Braver, Carter, Poldrack, & Robbins). Tests were administered and scored in accordance with test manuals or as indicated in previous research.

Test measures are described by the cognitive domains and the sub-domains for which composite scores were derived (see later in this section, for details), as follows:

Processing speed.

Three tasks were used to derive indices of simple processing speed.

1) *CANTAB Reaction Time* (RTI) indexes processing speed and reaction time (Lezak, Howieson, & Loring, 2004; Strauss, Sherman, & Spreen, 2006). The participant quickly released the press pad and touched the monitor when a yellow dot appeared. Validity includes sensitivity to attentional dysfunction in attention-deficit/hyperactivity disorder (Gau & Huang, 2014); and adequate reliability is reported (Housden et al., 2014, October). The variable of interest is mean interval from stimulus onset to press pad release, measured in milliseconds: *RTI-RT*.

2) *Test A of the Trail Making Test* (TMT, Reitan & Wolfson, 1985; for protocol, see Strauss, et al., 2006) was also used. The TMT assays speed of visual search, attentional abilities, visuo-spatial sequencing, working memory, and set shift ability (for discussions, see Sanchez-Cubillo et al., 2009; Strauss, et al., 2006). There are two trials: In TMT-A, the participant connected a number sequence (1-2-3…). TMT-B is described below. Both have satisfactory validity and reliability (for review, see Strauss, et al., 2006). *TMT-A-Total* is time to completion, measured in seconds, and was the TMT measure of simple processing speed used here.

3) *D-KEFS Colour-Word Interference Test (C-WIT) Colour Naming* and *Word Reading* scores were used to index speed of processing (Delis, Kaplan, & Kramer, 2001a). The participant named colours of patches and read names of colours presented in black font (e.g., GREEN, RED) for Colour Naming and Word Reading, respectively. The technical manual (Delis, Kaplan, & Kramer, 2001b) reports acceptable psychometric properties. *Colour Naming-Total* and *Colour Reading-Total* are completion times measured in seconds.

Attention.

The broader domain of attention was subdivided to distinguish between the subdomains of span of attention and sustained attention, as follows.

Span of attention. For this sub-domain, three tasks were used:

1) *Digit Span Forward* (DSF, Wechsler, 2008) assays span of attention for verbally-based information (Lezak, et al., 2004). The participant repeated number sequences as presented. The test authors (Wechsler) report adequate psychometric properties for combined estimates of digit-span variables: *DSF-Total* is total correct responses (maximum = 16).

2) *CVLT-II Trial 1* (Delis, et al., 2000) measures span of attention for auditory information (see also the subsection, Memory, for more detail of the CVLT-II). Here we focus on the participant's recall of words following first presentation of a 16-item list. The test authors report reliability as somewhat low; however, exposure may influence subsequent test-taking strategy (Delis, et al.). *CVLT-Trial 1-Total* is the number of words recalled.

Vigilance/sustained attention. Two tasks were used to index this subdomain.

1) *CANTAB Rapid Visual Information Processing* (RVIP) measures sustained attention for visual information and processing speed (Smith, Need, Cirulli, Chiba-Falek, & Attix, 2013; Strauss, et al., 2006); and shares similarity with the Continuous Performance Test (Rabin, Barr, & Burton, 2005; Rosvold, Mirsky, Sarason, Bransome Jr., & Beck, 1956). In performing the test, a four-minute stream of pseudo-random single digits are briefly presented on the monitor; and the participant pressed the pad within 1.8 seconds following presentation of any of three specified three-digit sequences (e.g., 3-5-7). Performance is sensitive to attentional dysfunction in attention-deficit/hyperactivity disorder (Gau & Huang, 2014); and *RVIP-A′*, the composite measure of the probability of a hit [*hits/(hits + misses)*] and probability of a false alarm [*total false alarms/(total false alarms + total correct rejections)*] is sensitive to attention dysfunction

in patients with first-episode schizophrenia (Hilti et al., 2010): *RVIP-A′* was calculated from Blocks 5-7 (range .00 - 1.00).

2) *The Auditory Digit Span Distraction Test* (ADSDT, Oltmanns & Neale, 1975) measures short-term recall and distractibility for auditory information during conditions of high momentary processing load. There are two trials: During the distraction trial, the participant recalled recorded digit sequences presented by a female voice, while ignoring digits presented by a male voice. For the non-distraction trial, they recalled digit sequences presented by a female voice only. The conditions are equally difficult in the normal population; however, the distraction condition is more difficult for people with schizophrenia (Oltmanns & Neale). The variables are the proportion of distraction trial digits recalled in the correct position (*ADSDT-distractible proportion* range: 0.00-1.00); and number of distractor digits recalled (*ADSDT-distractible intrusions*).

Memory.

Two tasks were used to derive measures of memory.

1) *CVLT-II* (see also above, Delis, et al., 2000) is among the most widely-used measures of verbal learning and memory in clinical assessment (Rabin, et al., 2005). It consists of two 16-item word lists (List A and B), each comprised of four words from four semantic categories. Following each of five List A learning trials, the participant recalled List A in any sequence. This was followed by an interference list (List B); then List A again (*short-delay free recall*); and then words belonging to each List A category following a cue for each category. After a 20-minute break in verbal testing, they recalled List A (*long-delay free recall*), followed by another cued recall of List A's categories, and then recognized List A words presented among foils (Yes/No). Construct validity has been reviewed (Delis, et al.; Paulsen et al., 1995); and the test authors report adequate reliability (Delis, et al.). The variables are *CVLT-short-delay free recall* and *CVLT-long-delay free recall*: maximum = 16 for both.

2) *CANTAB Paired Associates Learning* (PAL) measures learning of pattern-location associations (Strauss, et al., 2006). During the learning trial, the participant viewed patterns that were revealed individually, each occupying a square located on the monitor. During the test phase, the patterns appeared individually, and they touched the square associated with each pattern. Errors resulted in another learning trial. Performance is sensitive to memory dysfunction in a range of conditions (for review, see Strauss, et al.); and adequate reliability is reported (Housden, et al., 2014, October). The variables are total presentations taken to locate all patterns in all stages (*PAL-total trials adjusted*); and total errors made at the 8-pattern stage (*PAL-total errors 8-shapes adjusted*): maximum = 80 for both.

Language/Semantic.

CANTAB Graded Naming Test (GNT) indexes semantic memory and picture word naming. The participant named 30 line drawings of things. Adequate reliability has been reported (Bird & Cipolotti, 2007; Bird, Papadopoulou, Ricciardelli, Rossor, & Cipolotti, 2004). *GNT-Total* is the number of correctly named objects.

Semantic.

Given interest in the role of semantic memory dysfunction in clinical studies of FTD in schizophrenia and debate about whether semantic difficulties in schizophrenia are related to access or storage problems, we decided against a single composite semantic measure. Instead, we distinguished between the following scores that could be derived from our battery:

Targeted access. *Typicality of first CF response* (typicality, Kiang & Kutas, 2006) was used as the first index of semantic functioning; and it measured targeted access of information in semantic memory. The participant listed ‘items of clothing’ and ‘fruit’ according to the CF protocol. Their first response for each category was scored according to its frequency as a first response in an Australian normative sample (Casey & Heath, 1988) according to procedures from Kiang and Kutas. For example, when responding to the prompt ‘fruit’, *typicality* for

'apple' or 'kiwi fruit' is 58% and 1%, respectively, with consequent scores of 58 and 1 to reflect typicality if generated as the first response; higher scores indicate stronger associative links between the category and the exemplar in semantic memory (Belohlavek, Klir, Lewis, & Way, 2009). The variable of interest is *Typicality-first,* comprised of typicality for 'fruit' and 'items of clothing', with *z*-scores for each contributed equally.

Structure/Organisation. *D-KEFS Category Fluency* (CF, Delis, et al., 2001a) measures verbal abilities, including efficiency of retrieval of words from the mental lexicon (for discussions, see Lezak, et al., 2004; Shao, Janse, Visser, & Meyer, 2014; Strauss, et al., 2006). The participant said as many different words belonging to a category (*fruit, four-legged animals, vehicles, action words*) as possible in one minute: administration was according to D-KEFS except for 'action words' which accorded with Badcock, Dragović, Garrett, and Jablensky (2011). CF's sensitivity to index semantic ability is supported by evidence of greater category than letter fluency (LF see below) impairment in conditions associated with semantic dysfunction (Henry & Crawford, 2005; Laws, Duncan, & Gale, 2010). The test authors report adequate reliability (Delis, et al.). The variable of interest was *CF-Total* (*z*-scores for each category contributed equally).

Higher-order reasoning.

Two tasks were used to index this cognitive domain.

1) *Sentence Arrangement* from the *WAIS-R as a Neuropsychological Instrument* (SA, Kaplan, Fein, Morris, & Delis, 1991) indexes sequential reasoning, planning capacity, and ability to construct syntactically-correct sentences (Lezak, et al., 2004). The participant re-assembled sequenced sets of words to construct meaningful and grammatically-correct sentences. They then read aloud the responses and stated whether they made a "good sentence". Performance is sensitive to left frontal lobe lesion associated with dynamic aphasia (Costello &

Warrington, 1989) and executive dysfunction in patients with schizophrenia (Gard, Harrell, & Poreh, 1999). The variable of interest is *SA-Total* (maximum = 20).

2) *Picture Arrangement* (PA, Wechsler, 1997) measures sequential reasoning and planning abilities (Lezak, et al., 2004). The participant sequenced pictures to construct a coherent story. Validity and reliability have been reviewed (Lezak, et al.; Strauss, et al., 2006). *PA-Total* is the total correct responses (maximum = 22).

Executive function.

Working memory. *CANTAB Spatial Working Memory* (SWM) assays spatial working memory and strategy use (Robbins et al., 1998). The participant touched squares on the monitor to reveal blue tokens that they placed in a column at the side of the monitor. They were instructed that once a token was found, the square that it was 'in' would remain empty for the rest of that trial; and new tokens would be hidden in squares that were, as yet, empty. In this way, they found the remaining tokens. Use of a repetitive search pattern (*SWM-strategy*) improves performance; and inefficient strategy use follows frontal lobe surgery (Owen, Downes, Sahakian, Polkey, & Robbins, 1990). Adequate reliability has been reported (Housden, et al., 2014, October). There were two variables of interest here: *SWM-within errors* (returning to an empty box in the same search episode) and *SWM-between errors* (returning to a square that previously contained a token).

Planning/Strategy use.

Three tasks were used to asses this subdomain.

1) *CANTAB Stockings of Cambridge* (SOC) assays spatial planning (Strauss, et al., 2006). The participant planned and moved balls in the lower display using the fewest moves to copy a pattern of three coloured balls in the upper display. Twelve trials were presented identical to the Tower of London (Shallice, 1982). Each trial had a yoked control condition, providing baseline measurement of time taken to initiate motor movement. Validity is supported by impaired

performance following frontal lobe lesion (Owen, Morris, Sahakian, Polkey, & Robbins, 1996). The two variables of interest are the number of problems solved in the minimum number of moves (*SOC-PS*: maximum = 12) and mean initial planning time for 5-move problems (*SOC-IPT = baseline initiation time – time of first touch in the test conditions*).

2) *The CANTAB SWM-strategy* score (see SWM description above) was also included to index strategy use: maximum = 56.

3) *CVLT-recall consistency* (see also description of CVLT above) indexes consistency of word recall across consecutive presentations of the word list, as may occur when changing learning strategies (for discussion, see Delis, et al., 2000). It is derived by calculating the percentage of words recalled on the first four learning trials that are recalled on each subsequent trial: Range = 0 - 100.

Generative ability. *D-KEFS LF* (Delis, et al., 2001a) measures generative ability and executive function (for discussions, see Lezak, et al., 2004; Shao, et al., 2014; Strauss, et al., 2006). The participant said as many different words that begin with a designated letter (F, A, S) as possible in one minute. Validity includes evidence linking performance with frontal lobe damage (Baldo & Shimamura, 1998; Baldo, Shimamura, Delis, Kramer, & Kaplan, 2001): The test authors report adequate reliability (Delis, et al.). Total correct responses were reported: *LF-Total* (sum of three trials).

Set maintenance/Response inhibition.

Two tasks assessed this subdomain.

1) *C-WIT Inhibition* (Delis, et al., 2001a) measures ability to suppress a habitual response in favour of a less habitual one (Strauss, et al., 2006). It is based on the classic Stroop (Stroop, 1935). Following colour naming and reading trials (see above), the participant named font colours of dissonant colour words (e.g., RED presented in blue font). There is a normally-occurring effect of slowing in this trial relative to Colour Naming that has been variously

attributed to response conflict, failure of response inhibition, or failure of selective attention (for discussion, see Lezak, 1995). The test authors report adequate reliability (Delis, et al.). *C-WIT-Inhibition* is seconds to completion.

2) *CANTAB Stop Signal Task* (*SST*) is a stop-signal response inhibition test. Arrows pointing either left or right were presented on the monitor, and the participant quickly pressed the ipsilateral press-pad button; however, they withheld response to an auditory signal. The delay between arrow stimulus (*go*) and auditory signal (*stop*) varied according to performance, so that stopping occurred about half of the time. The duration between *go* and *stop* influences the likelihood of not responding: with more success on briefer intervals. The variable, *Stop Signal RT* (*SST-SSRT*), was derived by subtracting RT on *go* trials from the delay at which the participant could stop 50% of the time for the last 20 sub-blocks: measured in milliseconds.

Set-shift.

Three tasks were used to assess this executive subdomain.

1) *CANTAB Intra-extradimensional Set Shift* (I-ED) measures rule acquisition and reversal, and attentional set formation, maintenance and shift ability (Strauss, et al., 2006). The participant selected one of two patterns on the monitor. They acquired a 'rule' following feedback (Correct/Wrong) that enabled correct selection of ensuing presentations. The rule changed after six consecutive correct responses; and they learned new rules in response to feedback: Attaining the rule for Stage 8 requires extra-dimensional shift of attention to previously irrelevant information (i.e., from sorting by shape to colour) as on the Wisconsin Card Sort Test (Heaton, 1981). Specific loss of extra-dimensional shift follows bilateral posteroventral pallidotomy, implicating frontostriatal neural systems with performance (Scott et al., 2002); and Stage 8 performance is sensitive to frontal lobe dysfunction (Brady et al., 2013; Kim, An, Kwon, & Shin, 2014). The variable is *I-ED-block-8 errors*.

2) *TMT-B* (see TMT description above) indexes set-shift ability. The participant connected a sequence of alternating numbers and letters (1-A-2-B…). *TMT-B-Total* is time to completion, measured in seconds.

3) SA Items 1-5, 7, and 8 (see SA description above) may load on set-shift ability, as these require separating strongly-associated words (e.g., HAIR-BRUSH) to make meaningful sentences (Gard, et al., 1999). The variable of interest is *SA-shift* (maximum = 14).

Source monitoring. *Reality Monitoring Task* (RMT, Johnson & Raye, 1981) indexes *source monitoring*, the ability to discriminate between memory for self-generated cognitive events (e.g., one's thoughts) and external phenomena. Our study used three word-lists (*say-*, *think-*, and *new-list*) derived from the hundred most-common English words (Thorndike & Lorge, 1944). Each *say*-list word was matched with *think*- and *new*-list words for length and frequency of use according to Bradley and Lang norms (1999). *Say*- and *think*-list words were individually presented in 96-font on the monitor in alternating fixed sequence (*say-think-say*…) for two seconds with two-second inter-stimulus interval. The participant alternated between saying items aloud (*say-list*) and imagining saying them aloud (*think-list*) with the instruction that they would later recall whether they said a word aloud or imagined saying it aloud. During recall trials, *say-list*, *think-list* and new words (*new-list*) were individually presented in randomly-ordered fixed sequence, and the participant stated whether they said it aloud, imagined saying it aloud, or if it was new. Performance has been linked to the medial anterior prefrontal cortex (Mitchell & Johnson, 2009), including poor performance in healthy individuals without paracingulate sulci (Buda, Fornito, Bergström, & Simons, 2011). The two variables of interest were total of *new-list* words reported as *say-list* (*RMT-new-as-say*), and total *think-list* words reported as *say-list* (*RMT-think-as-say*).

To summarise, Table 1 lists the test variables comprising the cognitive domains and sub-domains considered for this study.

Table 1

Summary of Test Variables Grouped According to Cognitive Domain and Subdomain

Cognitive Domain Cognitive Sub-Domain	Test Variable
Processing speed	RTI-RT, TMT-A-Total, Colour Naming-Total, Colour Reading-Total
Attention	
Span of attention	DSF-Total, CVLT-Trial 1-Total
Vigilance/Sustained attention	RVIP-A′, ADSDT-distractible proportion, ADSDT-distractible intrusions
Memory	CVLT-short-delay free recall, CVLT-long-delay free recall, PAL-total trials adjusted, PAL-total errors 8-shapes adjusted
Language/Semantic	GNT-Total
Semantic	
Targeted access	Typicality-first
Structure/Organisation	CF-Total
Higher order reasoning	SA-Total, PA-Total
Executive function	
Working memory	SWM-within errors, SWM-between errors
Planning/Strategy use	SOC-PS, SOC-IPT, SWM-strategy, CVLT-recall consistency
Generative ability	LF-Total
Set maintenance/Response inhibition	C-WIT-Inhibition, SST-SSRT
Set shift	I-ED-block-8 errors, TMT-B-Total, SA-shift
Source monitoring	RMT-new-as-say, RMT-think-as-say

Procedure

Participants partook in an interview to collect demographic, clinical, and personality information, underwent the cognitive screening, and completed the SPQ, BPQ, DASS-21, and SDS questionnaires displayed on the monitor. They were then interviewed and they described pictures to collect the speech samples that would be rated for FTD using the TLC and TLI (detailed in Paper 1), and to complete the LDU. They then performed the neuropsychological battery in fixed order: RTI, LF, SST, SA, SOC, CF, I-ED, C-WIT, RVIP, RMT, PAL, ADSDT, GNT, TMT, CVLT-II, PA, SWM, and DSF. Interviews and assessments were performed by CD.

Statistical Analyses

We sought to describe relationships between different dimensions of cognitive function and FTD in a community-based sample of homeless young adults with elevated schizotypal traits.

To address the main aim, we investigated relationships between PCA-derived TLC/TLI dimensions of FTD and cognitive test performance: The TLC/TLI dimensions for this sample were reported in detail in Paper 1. To minimize test-specific influences on relationships, reduce measurement error, and provide more stable estimates of the putative cognitive domains and subdomains, most cognitive domains were represented by composite measures. This included 'standardizing' test variables to provide a common metric; weighting variables contributing to a composite, and where a test contributed two variables to a composite, these variables were weighted to 'equalize' the contributions of the different tests to the overall composite (e.g., CompositeA = (TestAVariableX/4 + TestAVariableY/4 + TestBVariableZ/2; thus TestA and TestB contributed equally). We used raw scores in analysis to increase variance; and because age adjustment in this cohort may decrease sensitivity to detect disease-related effects on cognition and FTD (for discussion, see

Mungas, Reed, Farias, & DeCarli, 2009). Test variables were transformed such that higher score indicated better performance.

Normally-distributed demographic, clinical, and personality data were analysed with independent *t*-test, and if non-normally-distributed with Mann-Whitney *U* test using Statistical Package for the Social Sciences Version 21. Power analysis, using software from Faul, Erdfelder, Buchner, and Lang (2009), indicated a sample of 90 as suitable for moderate correlation ($r = .36$, $\alpha = .05$, two-tailed, power = .95), as is typically reported in the relevant neuropsychological literature (Kerns & Berenbaum, 2002). As the study was exploratory, tests were two-sided for the main hypothesis; and we controlled for multiple comparisons using Benjamini-Hochberg procedure at $\alpha = .10$, as it is more powerful than Bonferroni correction and recommended by McDonald (2009). In comparison and for clarification, Bonferroni correction would have set a very stringent $p \leq .0007$ to maintain the likelihood of a single false positive. But this increases the likelihood of rejecting actual relationships, demonstrating that Bonferroni correction is most useful with more pointed hypothesis testing (for discussion, see McDonald). Differences between group means were calculated using software made available by Uitenbroek (1997); and effect size estimates were derived using software obtained from Lenhard and Lenhard (2015). To test the specificity of observed correlations between particular cognitive scores and particular TLC/TLI dimensions of FTD, the significance of differences between correlation coefficients were tested using Steiger's *z*-tests (1980) and software made available by Lee and Preacher (2013). In a post-hoc exploratory investigation for each TLC and TLI dimension, we then performed backward deletion multiple regression incorporating cognitive domain variables identified as 'significant' following Benjamini-Hochberg step-up. Since these were exploratory post-hoc regressions, the alpha for exclusion was set at .10.

Preliminary Investigations

Inspection of Q-Q plots and skewness, kurtosis and Shapiro-Wilk tests ($p < .05$) indicated DASS-Depression and -Anxiety, LDU-C and -A, and SDS-C and -A as positively skewed. These distributions were sufficiently normalized ($\alpha < .05$) following square-root transformation. Non-normally-distributed cognitive variables were logarithmically, square root, or inversely transformed as appropriate to produce approximately normal distribution (Appendix Table A1). Missing data (< .5%; primarily equipment failure) were replaced by mean score. Visual inspection of scatterplots of relevant combinations of variables did not indicate curvilinearity or violation of homoscedasticity. Bivariate and multivariate normality were examined using Mahalanobis distance, and univariate outliers (< 1%) were winsorised. Data from one participant was omitted due to multivariate outlying effects, leaving data from 91 participants for analysis.

Results

Sample Characteristics: Basic Demographic, Clinical, and Personality Descriptives

Appendix Table A1 summarises basic demographic and personality inventory descriptives for the 91 participants whose data was used to address the main aim of this paper. Note: The reader will find a fuller description of the current sample in Paper 1, with the small caveat that one participant from Paper 1 was excluded from this analysis (Paper 2) due to multivariate outlying effects. In brief, this sample of young adults was comprised of roughly equal numbers of males and females (n = 52 and 39, respectively), about 10 years of formal education, and average-range IQ. In this sample, substance abuse and dependence were prevalent: 56 participants (62%) met DSM-IV criteria for current or prior abuse or dependence. General psychological distress was elevated: DASS-Depression, -Anxiety, and -Stress scores were at, or above, the normative 95th centile (Crawford, Cayley, Lovibond, Wilson, & Hartley,

2011) for 16 (18%), 18 (20%), and 10 (11%) participants, respectively; and 6 (7%) were being treated for depressive disorder.

Schizotypal and borderline traits were also elevated: Independent-samples t-test revealed greater SPQ Total score for this sample (M = 34.8, SD = 15.3) than a large normative sample derived from university students from New Zealand (N = 1,424, age 16-25 years, 69% female; G. M. Grimshaw, personal communication, May 19, 2014), M = 23.9, SD = 12.3): $t(97.1) = 6.6$, $p < .001$, two-tailed. The magnitude of the difference was large, M difference = 10.9; 95% CI 7.6 - 14.1; $d_{Cohen} = .87$. SPQ Total for 38 participants (42%) fell above the normative 90th centile; and 13 (14%) participants met DSM-IV SPD criteria. BPQ Total for 37 (41%) participants fell above the normative 90th centile (Poreh, et al., 2006).

FTD scales.

TLC and TLI ratings for the original sample (N = 92) are fully reported in Paper 1.

TLC. Item ratings were 'clinically-elevated' for 63 (68%) participants. Relative to patients with schizophrenia, mean ratings for *tangentiality, derailment,* and *loss of goal* were comparable; *word approximations* and *self-reference* were elevated; and *poverty of speech* was reduced. Only 16 participants (17%) demonstrated no disturbance. PCA described three components that explained 63% of the variance. Component 1, labelled Disorganisation was comprised mainly of *loss of goal*, *derailment*, and *tangentiality*; and appeared to reflect difficulty maintaining goal in speech. Component 2, labelled Verbosity, was made up of *circumstantiality, pressure of speech,* and *word approximation*. Component 3, labelled Emptiness, appeared to reflect paucity of thought: *poverty of content of speech* and *perseveration*.

TLI. Mean item ratings for *poverty of speech* and *perseveration of ideas* were similar to patients with schizophrenia, while the remaining item levels were similar to healthy adults. Only seven participants (8%) had ratings of zero for all items. A two-component solution was

selected following PCA explaining 58% of the variance: Component 1 was labelled Negative, as it appeared to reflect poverty of thought and speech. The second component, labelled Idiosyncratic, was thought to reflect a peculiar use of language.

Cognitive Performances

Appendix Table A1 also summarises the cognitive raw scores that were the basis for computing the cognitive domain/subdomain composite scores that were used in the correlational analyses. In brief, cognitive domain performances (Colour Naming, DSF, CVLT-long-delay-free recall, PA, SWM between errors, SWM-strategy, LF, C-WIT-Inhibition) for the sample fell within the *average* range (Wechsler, 1997) relative to same-age normative reference groups, with the exception that the sample's performance was within the *borderline* range on the GNT. The *borderline* range GNT performance may reflect cultural differences between our Australian sample and the UK normative sample (for discussion, see Lezak, Howieson, Bigler, & Tranel, 2012). For instance, Roberts (2003) found substantive group differences between their English-speaking Canadian sample and the UK normative sample in ability to name 12 of the GNT items: For example, 93 percent of the UK sample correctly named 'sporran' compared to 21 percent of the Canadian sample; whereas 73 percent of the Canadian sample correctly named 'tutu' versus 25 percent of the UK sample.

Correlational Analysis

Relationships between TLC/TLI dimensions and demographic, and clinical variables.

To identify variables that potentially influence the TLC/TLI-cognitive domain relationships, we examined correlations between TLC/TLI dimension scores and background variables representing age, education, substance use (LDU and SDS), and psychological distress (DASS): all 2-tailed. The only statistically significant relationship was between greater TLC Disorganisation score and increasing severity of cannabis dependence, $r = .25$, $p = .02$.

Relationships between cognitive domain and TLC/TLI dimension scores.

Table 2 reports correlations between the different TLC/TLI dimension scores and cognitive domain composite variables. The significant relationships indicated following Benjamini-Hochberg procedure performed for all 70 correlations simultaneously are highlighted in bold.

Commenting first on correlations with the three TLC dimension scores, following Benjamini-Hochberg procedure, greater TLC Disorganisation score was related to poorer performance in cognitive domains of memory, language/semantic, higher-order reasoning, set maintenance/response inhibition, and set shift abilities. Higher TLC Emptiness score was associated with poorer semantic structure/organization, higher-order reasoning, and set shift scores. Of note, higher TLC Verbosity score was linked instead to ***better*** cognitive functioning as indicated on the language/semantic, semantic structure/organization, higher-order reasoning, planning/strategy use, generative ability, and set shift domain variables.

With respect to correlations with the two TLI dimensions, following Benjamini-Hochberg procedure, higher TLI Negative score was linked to worse performance on nine of 14 cognitive domains, including span of attention, vigilance/sustained attention, language/semantic, semantic structure/organization, higher-order reasoning, planning/strategy use, generative ability, set maintenance/response inhibition, and set shift. Of note, a pattern of relationships emerged in the zero-order correlations between increasing severity of TLI Negative and impairment on all three attention variables (i.e., indexing processing speed, span of attention, and vigilance/sustained attention). Finally, after correction for the false positive rate, increasing severity of TLI Idiosyncratic was related to poorer performance on the language/semantic, higher-order reasoning, and planning/strategy use dimensions.

In sum, of the cognitive domains, only processing speed, semantic/targeted access, working memory, and source monitoring were unrelated to any of the TLC/TLI dimensions following Benjamini-Hochberg correction for the false positive rate.

Table 2 reports TLC/TLI-cognitive domain correlation coefficients compared across TLC/TLI dimensions. Again, Benjamini-Hochberg procedure was performed for all 70 correlations simultaneously; and the significant relationships are highlighted in bold. Overall, the TLC/TLI dimensions were differentiated by different patterns of relationship with the cognitive domain variables. Notably, all but one differential pattern was driven by the predominantly ***positive*** direction of the relationships between TLC Verbosity scores and cognitive performance, which was opposite the principally negative relationships between the remaining TLC/TLI composites and the cognitive domain variables. The exception was that TLI Negative and TLI Idiosyncratic were weakly differentiated by their relationships with the processing speed dimension, although it is acknowledged that neither correlation had reached significance following the Benjamini-Hochberg procedure. The contribution of cognitive dysfunction to TLI Idiosyncratic and TLC Emptiness was less clear. Along this line, TLI Idiosyncratic and TLC Emptiness were indistinct from TLC Disorganisation with respect to their cognitive relationships.

In order to establish better generalisation of findings to clinical samples, we subsequently re-examined the same TLC/TLI-cognitive relationships for a subsample of participants with the highest schizotypal trait scores (i.e., > 90^{th} centile on population norms): The general pattern of FTD-cognitive relationships for the subsample (n = 38) was comparable to the pattern of relationships reported for the total sample.

Table 2

Correlations between TLC/TLI and cognitive domain dimensions; and Steiger's z-tests comparing TLC and TLI dimensions on relationships with cognitive domain dimensions (N = 91; 2-tailed).

	TLC			TLI		
Variable	Disorganisation	Verbosity	Emptiness	Negative	Idiosyncratic	Significant Steiger's z-test
Processing speed	-.06 (.55)	.14 (.20)	-.05 (.65)	-.21 (.04)	.06 (.59)	c: **2.1***; e: **-2.1***
Span of attention	-.01 (.93)	.21 (.05)	-.18 (.10)	**-.26 (.01)**	-.13 (.21)	b: **2.4***; c: **3.2****; d: **2.6****
Vigilance/Sustained Attention	-.14 (.19)	.08 (.48)	-.15 (.17)	**-.23 (.03)**	-.18 (.09)	
Memory	**-.28 (.01)**	.05 (.61)	-.03 (.78)	-.16 (.13)	-.18 (.08)	a: **2.2***
Language/Semantic	**-.33 (<.01)**	**.23 (.03)**	-.04 (.71)	**-.25 (.02)**	**-.30 (<.01)**	a: **3.7****; c: **2.9****; d: **4.3****
Semantic: Targeted Access	.07 (.50)	-.17 (.11)	-.08 (.44)	.05 (.61)	-.14 (.19)	
Semantic: Structure/Org	-.11 (.29)	**.23 (.03)**	**-.24 (.02)**	**-.22 (.04)**	-.12 (.24)	a: **2.2***; b: **3.0****; c: **2.7****; d: **2.7****
Higher-order reasoning	**-.33 (<.01)**	**.23 (.03)**	**-.26 (.01)**	**-.39 (<.01)**	**-.27 (.01)**	a: **3.8****; b: **3.1****; c: **3.8****; d: **3.9****
Working memory	-.01 (.96)	.09 (.41)	-.03 (.78)	-.12 (.27)	-.11 (.29)	
Planning/Strategy use	-.19 (.07)	**.25 (.02)**	-.14 (.19)	**-.22 (.04)**	**-.23 (.03)**	a: **2.9****; b: **2.5****; c: **3.8****; d: **3.8****
Generative ability	-.07 (.51)	**.28 (.01)**	-.20 (.05)	**-.26 (.01)**	-.08 (.47)	a: **2.3***; b: **3.1****; c: **3.3****; d: **2.8****
Set maintenance/Resp Inhib	**-.29 (.01)**	.19 (.08)	-.13 (.21)	**-.28 (.01)**	-.20 (.05)	a: **3.2****; b: **2.0***; c: **2.8****; d: **3.1****
Set shift	**-.26 (.01)**	**.24 (.02)**	**-.23 (.03)**	**-.39 (<.01)**	-.22 (.04)	a: **3.4****; b: **3.0****; c: **4.0****; d: **3.6****
Source monitoring	-.18 (.08)	.10 (.32)	.05 (.65)	-.10 (.32)	-.15 (.17)	

Note. **Bold** = significant following Benjamini-Hochberg step-up procedure. TLC = Scale for Thought, Language and Communication (Andreasen, 1986); TLI = Thought and Language Index (Liddle, et al., 2002); Org = Organisation; Resp Inhib = Response Inhibition; Steiger's *z*-test: a = Verbosity versus Disorganised; b = Verbosity versus Emptiness; c = Verbosity versus Negative; d = Verbosity versus Idiosyncratic; e = Negative versus Idiosyncratic.

*$p \leq .05$, ** $p \leq .01$.

Effects of cannabis dependence on relationships between cognitive and TLC/TLI dimension scores.

We thought it plausible that factors relating to substance use may be linked to cognitive dysfunction and/or FTD either causally (i.e., via neurotoxicity) or indirectly (e.g., substance use to self-medicate symptoms). As we found that greater cannabis dependence (SDS-C) was linked to greater severity of TLC Disorganisation dimension score, we considered whether current cannabis dependence may be indexing acute toxic effects of cannabis, and if so, whether this may influence the identified cognitive domain-TLC Disorganisation relationships. Thus, we reconsidered the above relationships with the TLC Disorganisation score partialling out the effects of SDS-C on these relationships: strengths of zero-order and partial correlation coefficients were similar, partial correlations between TLC Disorganisation and each of memory (r = -.26, p = .01), language (r = -.31, p = .002), higher-order reasoning (r = -.32, p = .001); set maintenance/response inhibition (r = -.28, p = .004); and set shift domain variables (r = -.21, p = .02) remained significant. Overall, this evidence provides support for the conclusion that the observed TLC/TLI-cognitive domain relationships in our sample are unrelated to cannabis use.

Post-hoc regression analyses predicting TLC/TLI dimension scores from cognitive domain scores.

In order to help condense the data reported in Table 2, Table 3 reports the final models produced by five regression analyses using backward deletion to identify the combinations of cognitive domains/subdomains that best independently predict each of the TLC/TLI dimension scores. For each analysis, all of the cognitive domain dimension variables that had substantive relationships with the TLC/TLI variable of interest (i.e., those significant following Benjamini-Hochberg procedure) were initially included.

TLC Disorganisation: The first regression initially included cognitive scores for memory, language/semantic, higher-order reasoning, set maintenance/response inhibition, and set shift ability with TLC Disorganisation being the predicted variable. The combination of scores for language/semantic and higher-order reasoning were significant and equally-contributing independent predictors of TLC Disorganisation, together accounting for 15% of the variance.

TLC Verbosity: The second regression predicted TLC Verbosity, and initially included cognitive scores of language/semantic, semantic structure/organization, higher-order reasoning, planning/strategy use, generative ability, and set shift ability. Generative ability and language/semantic together were significant and roughly equally-contributing independent predictors of TLC Verbosity, accounting for 11% of the variance.

TLC Emptiness: For the third regression, which predicted TLC Emptiness, score for semantic structure/organization, higher-order reasoning, and set shift functioning were entered into the analysis initially. Only higher-order reasoning was identified as a predictor of TLC Emptiness, and explained merely 7% of scores on the TLC Emptiness dimension.

TLI Negative: The fourth regression to predict the TLI Negative dimension initially included measures of span of attention, vigilance/sustained attention, language/semantic, semantic structure/organization, higher-order reasoning, planning/strategy use, generative ability, set maintenance/response inhibition, and set shift ability. The combination of set shift ability and higher-order reasoning dimensions were significant and equally-contributing independent predictors of TLI Negative, together accounting for 18% of the variance.

TLI Idiosyncratic: The last regression, which identified predictors of TLI Idiosyncratic scores initially included measures of language/semantic, higher-order reasoning, and planning/strategy use: Language/semantic functioning indexed by the GNT was identified as the sole predictor; but explained only 9% of the total variance in TLI Idiosyncratic score.

Table 3

Backward Deletion Multiple Regression of FTD Dimension Scores Predicted from Cognitive Dimension Scores (N = 91)

	Model				Contribution of variable				
	Variance	Analysis			Weight			Analysis	
TLC/TLI Dimension Cognitive Domain Dimension	R^2	*F*	*df*	*p*	*B*	*SEB*	β	*t*	*p*
TLC Disorganisation	.15	7.65	1, 87	.001					
Constant					1.80	.03			
Language/Semantic					-.06	.03	-.23	-2.07	.04
Higher-order reasoning					-.06	.03	-.23	-2.08	.04
TLC Verbosity	.11	5.40	1, 87	.006					
Constant					.35	.02			
Generative ability					.03	.02	.18	1.70	.09
Language/Semantic					.04	.02	.24	2.37	.02
TLC Emptiness	.07	6.42	1, 88	.013					
Constant					.38	.02			
Higher-order reasoning					-.04	.02	-.26	-2.53	.01
TLI Negative	.18	9.92	1, 87	<.001					
Constant					.31	.02			
Set shift					-.04	.02	-.24	-1.90	.06
Higher-order reasoning					-.04	.02	-.23	-1.76	.08
TLI Idiosyncratic	.09	9.07	1, 88	.003					
Constant					.34	.02			
Language/Semantic					-.05	.02	-.30	-3.01	<.01

Note. R^2 = multiple correlation squared; F = F distribution; *df* = degrees of freedom; p = probability; B = unstandardized Beta; *SEB* = standard error of Beta; β = standardised Beta; t = Student's *t*.

Post-hoc relationships between affective dysregulation and TLC Verbosity score.

We thought it plausible that dysregulated affect may contribute to verbal overproductivity as represented by TLC Verbosity, perhaps reflecting hypomanic traits within the sample. Thus, we investigated correlations between TLC Verbosity score and ratings of constricted/inappropriate affect on the SPQ and the SCID-II, as well as the BPQ subscales *impulsivity, affective instability, abandonment, unstable relationships, self-mutilation, emptiness, and intense anger.* Only increasing severity of TLC Verbosity associated with **lower** levels of constricted/inappropriate affect on the SPQ (r = -.27, p = .01, n = 91) and SCID-II (r = -.22, p =.04, n = 89).

Summary. The key findings are that in this sample with elevated schizotypal traits, TLC Disorganisation appears to be driven primarily by a combination of language/semantic impairment and higher-order/executive dysfunction; while aspects of executive dysfunction were the strongest determinants of TLI Negative. The contribution of cognitive dysfunction to TLI Idiosyncratic and TLC Emptiness were less clear; and these were not differentiated from TLC Disorganisation or TLC Negative by their cognitive relationships. In contrast, TLC Verbosity was predicted by stronger cognitive functioning, principally related to verbal generative ability and language/semantic functioning.

Discussion

Our primary aim was to investigate the cognitive correlates of formal thought disorder (FTD) using the continuum approach. Informing this aim, FTD has consistently been associated with executive dysfunction and impaired processing of semantic information in patients with schizophrenia (Kerns & Berenbaum, 2002); however, variability in previous findings may relate to patient status and clinical confounds; and few studies examine cognitive relationships with different dimensions of FTD (for discussion, see Kerns & Berenbaum). Thus, using the continuum approach, which is free of confounding effects of patient status, we investigated the

cognitive correlates of different dimensions of FTD in a sample of homeless young adults with elevated schizotypal traits recruited from two large youth homeless services. Principal components analysis of two FTD rating scales identified dimensions of FTD for this sample in our previous study (Paper 1), and participants' FTD dimension scores from that study were used in this current analysis: the Scale for the Assessment of Thought, Language and Communication (TLC, Andreasen, 1978) and the Thought and Language Index (TLI, Liddle, et al., 2002). Participants completed a comprehensive neuropsychological battery representing 14 domains and subdomains of functioning.

We had one general hypothesis: that significant relationships exist between dimensions of cognitive functioning and FTD in persons with elevated schizotypal traits. As this study was exploratory, tests were two-sided for the main hypothesis. While we had no specific expectations, our secondary aim was to compare relationships between dimensions of FTD and cognitive functioning across different dimensions of FTD. We also examined whether these relationships were independent of demographic and clinical variables.

Associations Between Cognitive Functioning and TLC/TLI Dimensions

Our findings provide support for our hypothesis of relationships between cognitive functioning and FTD in individuals with elevated schizotypal traits. Post-hoc regression analysis indicated that TLI Negative was most strongly associated with a *combination* of impaired set shift and higher-order reasoning ability; and for TLC Disorganisation these were a *combination* of higher-order reasoning and language/semantic dysfunction. Less strongly, though still significantly identified, TLI Idiosyncratic and TLC Emptiness were best predicted by language/semantic and higher-order reasoning dysfunction, respectively. In contrast, TLC Verbosity, which was related to *stronger* cognitive functioning, was best predicted by stronger verbal generative ability and language/semantic functioning. Thus, higher-order reasoning, executive (set shift and generative ability), and language/semantic abilities were the likely

drivers of FTD in our sample. As FTD was unrelated to processing speed, targeted access to semantic information, working memory, or source monitoring ability, FTD in our sample is unlikely to relate to generalized cognitive dysfunction.

We were also curious to investigate whether the FTD dimensions had different cognitive profiles; and we found this to be supported: TLC Verbosity was distinguished from the other FTD dimensions on all cognitive dimensions except vigilance/sustained attention ability, targeted access to semantic information, and working memory function. Some evidence indicates that PFTD and NFTD (poverty of speech) are distinguished by different patterns of cognitive dysfunction in patients with schizophrenia or schizoaffective disorder (Berenbaum, et al., 2008). In our analysis, it was not possible to *significantly* distinguish TLC Disorganisation, TLC Emptiness, TLI Negative and TLI Idiosyncratic from each other by their cognitive relationships; but, a pattern of relationships emerged between increasing severity of TLI Negative and impairment of processing speed, span of attention, and vigilance/sustained attention, suggesting a possible link between NFTD and attentional impairment more broadly. If attentional dysfunction is associated with NFTD, how might we account for the absence of a relationship between attentional impairment and TLC Emptiness in our analysis, given that TLC Emptiness is conceptually related to TLI Negative? We suggest that this may be due to a relationship between attentional dysfunction and poverty of speech; and poverty of speech was indexed only by TLI Negative. We highlight that these are speculative suggestions; and acknowledge that the associations between TLI Negative and measures of processing speed, span of attention, and vigilance/sustained attention were small in magnitude. Overall, from the evidence in our sample, we cannot conclude that NFTD and PFTD are not differentiated by their cognitive profiles, simply that we were unable to find evidence supporting a distinction, possibly reflecting insufficient power to detect significant differences in magnitudes of correlation coefficients.

Associations Between TLC/TLI Dimensions and Demographic, and Clinical Variables

There was a small relationship between increasing severity of recent cannabis dependence and higher TLC Disorganisation score, but cannabis dependence was independent of the FTD-cognitive relationships. One possibility for the relationship between cannabis dependence and TLC Disorganisation, is that recent heavy cannabis use may be exacerbating FTD and other psychosis-like symptoms in some of our sample, perhaps via acute neurotoxic effects of cannabis or alterations of dopamine transmission. Some evidence suggests that cannabis use or dependence may worsen or accelerate symptoms of psychosis in groups at high risk for psychosis. For example, increasing severity of cannabis dependence for the previous six months has been shown to predict greater FTD severity at presentation in first-episode psychosis (Stone et al., 2014); and consistent evidence links cannabis use and earlier age of onset of psychotic illness (Large, Sharma, Compton, Slade, & Nielssen, 2011). We found no relationship between FTD and age, education, lifetime quantity of cannabis or alcohol consumption, recent severity of alcohol dependence, or recent psychological distress.

Comparisons of Cognitive-FTD Relationships in Current Sample with Previous Research

We sought to evaluate whether the FTD-cognitive relationships in our sample were indicative of relative abnormalities seen more towards the extreme clinical end of the schizophrenia spectrum, as we considered it conceivable that FTD is a continuum phenomenon also expressed to variable degree in the general-community and related to cognitive ability. In regard to findings concerning the lower end of the spectrum, Remberk, Namyslowska, and Rybakowski (2012) found TLC Total score unrelated to cognitive functioning, including typicality of semantic associations, span of attention, working memory ability, letter or category fluency performance, or executive function in general-community adolescents who were not distinguished with regard to levels of schizotypal traits. Of note, we also found no relations between FTD and typicality of semantic associations, working memory ability, and

source monitoring (an executive function) in the current study, reinforcing the need for an extensive cognitive battery in future related research. In contrast, limited findings from previous continuum-design research in undergraduate samples with elevated schizotypal traits shows greater severity of communication disturbances has been associated with more aberrant visual context processing (Uhlhaas, et al., 2004). Also, under stress-induction, increasing severity of communication disturbances in undergraduates has been linked with working memory impairment (Kerns & Becker, 2008) and semantic dysfunction (Minor, et al., 2011). The absence of similar findings during non-stress-induction conditions may reflect limited variability of communication disturbances in these highly-educated individuals and/or a reliance on insensitive tests, which is in keeping with evidence that undergraduate samples are consistently less variable on constructs of interest in psychological research (Peterson, 2001). This may also account for why some research does not report a link between communication disturbance and schizotypal traits in undergraduate samples (Weinstein, et al., 2008). Overall, previous continuum research provides very limited evidence suggesting that FTD is associated with cognitive dysfunction. Thus, our findings are significant for reporting relationships between FTD and cognitive function in a general-community sample with elevated schizotypal traits. It is noteworthy that the pattern of FTD-cognitive relationships reported for the sample as a whole (with elevated schizotypal traits on average) was comparable to a subsample of participants with elevated schizotypal traits (these 38 participants had scores > 90^{th} centile on population norms), increasing confidence that the findings generalize to clinical samples. However, we also acknowledge as a possibility that other unmeasured constructs such as levels of autistic traits or developmental trauma may account for the observed FTD-cognitive relationships in our sample with elevated schizotypal traits.

With respect to related FTD research in patient samples, evidence consistently associates FTD with executive dysfunction and impaired processing of semantic information in patients

with schizophrenia; and with language production dysfunction at a trace (Kerns & Berenbaum, 2002). In keeping with this, Tan and Rossell (2014) linked *both* semantic (recall of lists of semantically-related words) and executive dysfunction with FTD in patients with schizophrenia or schizoaffective disorder; and Remberk, Namyslowska, and Rybakowski (2012) reported similar findings in adolescents with early-onset schizophrenia spectrum disorder. Among studies that examine cognitive relationships with PFTD and NFTD (poverty of speech) separately, our zero-order correlation findings correspond closely with those of Berenbaum, Kerns, Vernon, and Gomez (2008). They found greater severity of PFTD related to poorer planning, working memory, memory, and naming performance; and more severe NFTD (poverty of speech) associated with poorer attention/concentration, planning, and generativity in outpatients with schizophrenia or schizoaffective disorder: Note that their planning measure was labelled as indexing higher-order reasoning ability in our study. They did report a link between PFTD and impaired working memory, which we did not; however, other research reports no link between FTD and working memory (Tan & Rossell, 2014), with the variability in findings possibly reflecting patient status.

Thus, overall our findings linking increasing severity of FTD (as represented by TLC Disorganisation, TLC Emptiness, TLI Negative and TLI Idiosyncratic) with dysfunction of higher-order reasoning, executive (set shift), and language/semantic abilities in persons with elevated schizotypal traits are compatible with findings from patients with schizophrenia (Kerns & Berenbaum, 2002). To the extent that the continuum hypothesis holds true, our results provide convergent evidence associating FTD with executive dysfunction and impaired processing of semantic information in schizophrenia. Given the concordance between evidence from our sample and previous research from patients with schizophrenia, it also seems plausible that FTD may represent increased risk for psychotic illness in some of our sample. In keeping with this, we reported in our previous paper (Paper 1) that FTD was linked to more

psychosis-like experiences on two measures in the same sample. In this regard, recent evidence indicates FTD as among the most predictive indicators for transition to psychosis in samples at high-risk for psychosis (Bearden, et al., 2011; Demjaha, et al., 2012; DeVylder, et al., 2014; Wilcox, et al., 2014). Evidence from our research also indicates the usefulness of the continuum approach to FTD research, including its cognitive correlates.

Cognitive Dysfunction and PFTD

Focusing first on features of PFTD, why might the TLC Disorganisation and TLI Idiosyncratic dimensions have been associated with similar cognitive dysfunction in our sample with elevated schizotypal traits (i.e., what may be the cognitive causes of PFTD)? Our findings indicate that some aspects of PFTD, as represented by TLC Disorganisation and TLI Idiosyncratic in our sample, reflect dysfunction of a) core language/semantic processes (e.g., accessing knowledge about the names of things, their attributes, and how things relate conceptually to other things), b) higher-order reasoning deficits, and c) difficulty maintaining set. With respect to possible effects of dysfunction of core language/semantic processes on PFTD, difficulty accessing words or links between concepts may lead to replies that are tangential or eventually derail, either because the speaker has not fully understood the initial questions, or because they could not access the most relevant connecting concepts to link ideas in their replies.

Our findings indicate that higher-order reasoning deficits (e.g., to combine and relate conceptual information) may also underlie some aspects of PFTD in our sample. This may be because difficulty linking concepts to form a coherent sequence, as required for our higher-order reasoning tasks, may cause monitoring deficits that cause speech to change direction (i.e., tangentiality and derailment). It may be that as access to information linking and relating ideas worsens, speech may appear increasingly disorganized, incoherent, or illogical to a listener; and more severe difficulty accessing words or their meanings may result in less conventional word

use and word invention as seen in speech that is empty of content. Along this line, some evidence links severity of higher-order reasoning impairment and dysfunction of core language abilities in patients with left hemisphere stroke-related aphasia (Baldo, Bunge, Wilson, & Dronkers, 2010; Baldo et al., 2005; Davidoff & Roberson, 2004; Hjelmquist, 1989; Kertesz & McCabe, 1975). For example, Lupyan and Mirman (2013) reported an association between dysfunction of the ability to categorise when this required focused attention and isolating several features of an object and severity of naming impairment in patients with left-hemisphere stroke-related aphasia: This relationship was not apparent for "low-dimensional" categorization tasks (e.g., categorizing by colour). Thus, it seems plausible that impairment of this higher-order reasoning function combined with dysfunction of core language/semantic processes contribute to disorganized speech.

Findings indicate that difficulty maintaining set may also compromise aspects of PFTD. This may occur because the ability of a speaker to keep speech on topic, resulting in tangential responding, or speech that is derailed or loses its goal. Although it is acknowledged that the executive ability to shift set associated most strongly with features of NFTD in our sample.

Cognitive Dysfunction and NFTD

Regarding possible cognitive bases of NFTD in our sample, we propose that some aspects of TLI Negative and TLC Emptiness in our sample may reflect a) higher-order reasoning deficits, b) executive dysfunction, c) core language/semantic impairment, and d) processing speed/attentional deficits. Our findings indicate that higher-order reasoning deficits, such as difficulty combining and sequencing related ideas, may limit one's ability to understand speech and to express ideas that are connected, giving rise to poverty of content, poverty of speech, and perseveration.

Our findings indicate executive dysfunction as a possible cause of NFTD in our sample. This may be because difficulty establishing set for topics of conversation may result in a

speaker being less prepared to respond, and consequently, their responses are relatively brief or are more "empty" of content. Another possibility, is that difficulty shifting set, may lead to repetition of themes and words, or difficulty shifting to different topics of conversation, similar to what has been proposed by McGrath (1991). Also, difficulty developing a speech plan may result in speech with less content. Findings indicate that dysfunction of core language/semantic abilities may also contribute to NFTD. This may occur because difficulty accessing words, their meaning, or links between concepts may make it difficult to understand a speaker, and generate a response, in the manner that we described as possibly contributing to PFTD.

Attention dysfunction may contribute to NFTD in several ways. Similar to Chapman and McGhie (1962), perceptual gating dysfunction may cause an overload of the information system, reducing the amount of information retained in mind and included in a discourse plan. Another possibility is that NFTD may arise from internal or external stimuli, or automatic responses that compete with a reduced capacity to maintain sustained attention on one's speech and thoughts (Persons & Baron, 1985), reducing the amount and content of speech. Also a possibility, attention dysfunction may contribute to NFTD indirectly, as higher-level abilities are reliant on intact attention capacity.

TLC Verbosity

An unanticipated relationship emerged between increasing severity of TLC Verbosity and *stronger* cognitive test performance, most strongly related to verbal generative ability and language/semantic functioning. In our previous paper (Paper 1) we also noted a similar relationship to verbal IQ. We are not aware of any similar finding in the literature; however, we speculate that it may relate to hypomanic traits that exist on a continuum, possibly reflecting a degree of affective dysregulation as is characteristic of some mood disorders, externalizing disorders, and borderline personality disorder (for discussion, see Kwapil et al., 2000). In our follow-up analyses we did not find evidence linking TLC Verbosity with affective

dysregulation, rather greater severity of TLC Verbosity related to lower levels of affective dysfunction. Some evidence also links hypomanic traits with schizotypal traits and severity of psychosis-like experiences (Kwapil, et al.); and genetic links between hypomanic facets of positive schizotypal traits have been described (Macare, Bates, Heath, Martin, & Ettinger, 2012). Findings from several studies associate hypomanic traits with higher verbal IQ, divergent thinking, and creativity in general-community samples (Furnham, Batey, Anand, & Manfield, 2008; Stringaris et al., 2014); and with cognitive flexibility during positive mood induction in undergraduates (Fulford, Feldman, Tabak, McGillicuddy, & Johnson, 2013). One possibility is that the TLC Verbosity-cognitive relationships reported in our sample share some aetiology with bipolar disorder. Along this line, bipolar disorder is associated with FTD (e.g., Harrow et al., 2000); and epidemiological evidence indicates superior premorbid verbal intelligence as a risk factor for later development of bipolar disorder (MacCabe et al., 2010), but this relationship may be specific to a "pure" form of bipolar disorder that possibly confers resilience to other psychiatric comorbidity (Gale et al., 2013). Perhaps the TLC Verbosity-cognitive relationships reported in our sample represents a protective factor that mitigates against developing a clinical psychotic disorder in a subgroup of adolescents with elevated schizotypal and hypomanic traits. We note that in our previous study (Paper 1), TLC Verbosity was unique among the TLC dimensions in not being associated with psychosis-like experiences.

Future Research

Future research might consider using the continuum approach to further investigate the cognitive relationships with different dimensions of FTD: This might include using more sensitive measures of attention to investigate whether NFTD and PFTD can be distinguished by their relationships with attentional functioning; and using a larger sample. Along this line, relationships between FTD and semantic disorganisation could be explored in more depth

than we were able, perhaps using more experimental measures. Also, the potential link that we described between hypomanic traits, FTD, and cognitive functioning may also merit examination. Cognitive relationships with other types of communication disturbance could also be examined using the continuum approach: As a follow-up to this investigation, we are examining relationships between schizotypal traits, cognitive functioning, and intrusions of associations into speech.

Limitations and Strengths

Following from our speculations about a possible relationship between mania and the unexpected relationship between TLC Verbosity and stronger cognitive functioning, a limitation is that we did not include a mania scale in our study. We had focused on the SPQ for obvious reasons. We also included the BPQ owing to the reported overlap between schizotypal and borderline personality traits in non-clinical young adults on the SPQ and BPQ (e.g., Fonseca-Pedrero, Lemos-Giráldez, Paino, Sierra-Baigrie, & Muñiz, 2012); and research reporting a high prevalence of psychotic symptoms (20-50%) in patients with Borderline Personality Disorder (for reviews, see Balaratnasingam & Janca, 2015; Gras, Amad, Thomas, & Jardri, 2014). This is an important direction for future research as mania and schizophrenia has been distinguished by different FTD subtypes (Andreasen, 1979b; Andreasen & Grove, 1986; Taylor, et al., 1994); and different FTD-cognitive relationships (Berenbaum, et al., 2008).

Strengths of this study include: use of two clinical rating scales to index FTD, allowing comparison between scales; use of the TLC, allowing direct comparison to research in patients with schizophrenia; TLC/TLI dimension scores were derived for our sample using PCA in our previous paper (Paper 1); cognitive relationships were investigated for each FTD dimension; and the false discovery rate was well-controlled, supporting reliability of the reported statistical relationships. Most cognitive dimensions were represented by composite

scores, limiting test-specific influences on analyses (e.g., differences in test sensitivity), reducing measurement error, and providing more stable estimates of the putative cognitive dimensions. The neuropsychological battery was broad; and we investigated fine-grained subdomains of attention, semantic and executive function. The sample was young and free of confounds relating to antipsychotic medications and institutionalisation; and they were also representative of the psychosocial adversity one would expect of a sample hypothesised to fall on the schizophrenia spectrum.

Conclusions

The substantive findings of this investigation include support for the conclusion of a relationship between FTD and cognitive function in general-community persons with elevated schizotypal traits; and these relationships were independent of demographic and clinical variables. To our knowledge, this is the first study to investigate the cognitive profile of different dimensions of FTD using the continuum approach. Higher-order reasoning ability, executive function (set shift and generative ability) and language/semantic functioning were the primary drivers of FTD. Four TLC/TLI dimensions were not substantially differentiated from each other by their cognitive relationships, which were in the direction of increasing severity of FTD linked with poorer cognitive functioning. However, distinct associations emerged between increasing severity of TLC Verbosity and stronger cognitive functioning.

References

Afifi, T. O., Mather, A., Boman, J., Fleisher, W., Enns, M. W., Macmillan, H., & Sareen, J. (2011). Childhood adversity and personality disorders: results from a nationally representative population-based study. *Journal of Psychiatric Research, 45*(6), 814-822. doi: 10.1016/j.jpsychires.2010.11.008

American Psychiatric Association. (1987). *Diagnostic and statistical manual of mental disorders (3rd ed., text rev.)*. Washington, DC: American Psychiatric Association.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (5th ed.)*. Washington, DC: American Psychiatric Association.

Andreasen, N. (1978). *The Scale for the Assessment of Thought, Language and Communication (TLC)*. Iowa City: The University of Iowa.

Andreasen, N. (1979a). Thought, language and communication disorders: I. Clinical assessments, definition of terms and evaluation of their reliability. *Archives of General Psychiatry, 36*(12), 1315-1321. doi: 10.1001/archpsyc.1979.01780120045006

Andreasen, N. (1979b). Thought, language and communication disorders: II. Diagnostic significance. *Archives of General Psychiatry, 36*(12), 1325-1330. doi: 10.1001/archpsyc.1979.01780120055007

Andreasen, N. (1986). *Scale for Assessment of Thought, Language, and Communication (TLC)*. Retrieved from http://psycnet.apa.

Andreasen, N., & Grove, W. M. (1986). Thought, language and communication in schizophrenia: Diagnosis and prognosis. *Schizophrenia Bulletin, 12*(3), 348-359. Retrieved from http://psycnet.apa.org

Andreou, C., Bozikas, V. P., Papouliakos, I., Kosmidis, M. H., Garyfallos, G., Kraravatos, A., & Nimatoudis, I. (2008). Factor structure of the Greek translation of the Scale for

the Assessment of Thought, Language and Communication. *Australian and New Zealand Journal of Psychiatry, 2008*(42), 636-642. doi: 10.1080/00048670802119721

Australian Psychological Society. (2003). APS Code of Ethics Retrieved from https://www.psychology.org.au

Badcock, J. C., Dragović, M., Garrett, C., & Jablensky, A. (2011). Action (verb) fluency in schizophrenia: Getting a grip on odd speech. *Schizophrenia Research, 126*(1–3), 138-143. doi: 10.1016/j.schres.2010.11.004

Balaratnasingam, S., & Janca, A. (2015). Normal personality, personality disorder and psychosis: current views and future perspectives. *Current Opinion in Psychiatry 28*(1), 30-34. doi: 10.1097/YCO.0000000000000124

Baldo, J. V., Bunge, S. A., Wilson, S. M., & Dronkers, N. F. (2010). Is relational reasoning dependent on language? A voxel-based lesion symptom mapping study. *Brain and Language, 113*(2), 59-64. doi: 10.1016/j.bandl.2010.01.004

Baldo, J. V., Dronkers, N. F., Wilkins, D., Ludy, C., Raskin, P., & Kim, J. (2005). Is problem solving dependent on language? *Brain and Language, 92*(3), 240-250. doi: 10.1016/j.bandl.2004.06.103

Baldo, J. V., & Shimamura, A. P. (1998). Letter and category fluency in patients with frontal lobe lesions. *Neuropsychology, 12*(2), 259-267. doi: 10.1037//0894-4105.12.2.259

Baldo, J. V., Shimamura, A. P., Delis, D. C., Kramer, J., & Kaplan, E. (2001). Verbal and design fluency in patients with frontal lobe lesions. *Journal of the International Neuropsychological Society, 7*(5), 586-596. doi: 10.1017/S1355617701755063

Barch, D. M., & Berenbaum, H. (1996). Language production and thought disorder in schizophrenia. *Journal of Abnormal Psychology, 105*(1), 592-601. doi: 10.1037/0021-843X.105.1.81

Barch, D. M., Braver, T. S., Carter, C. S., Poldrack, R. A., & Robbins, T. W. (2009). CNTRICS final task selection: executive control. *Schizophrenia Bulletin, 35*(1), 115-135. doi: 10.1093/schbul/sbn154

Barnett, J. H., Robbins, T. W., Leeson, V. C., Sahakian, B. J., Joyce, E. M., & Blackwell, A. D. (2010). Assessing cognitive function in clinical trials of schizophrenia. *Neuroscience and Biobehavioral Reviews, 34*(8), 1161-1177. doi: 10.1016/j.neubiorev.2010.01.012

Bazin, N., Lefrere, F., Passerieux, C., Sarfati, Y., & Hardy-Bayle, M. C. (2002). Formal thought disorders: French translation of the Thought, Language and Communication assessment scale. *Encephale, 28*(2), 109-119. Retrieved from http://europepmc.org

Bearden, C. E., Wu, K. N., Caplan, R., & Cannon, T. D. (2011). Thought disorder and communication deviance as predictors of outcome in youth at clinical high risk for psychosis. *Journal of the American Academy of Child and Adolescent Psychiatry, 50*(7), 669-680. doi: 10.1016/j.jaac.2011.03.021

Belohlavek, R., Klir, G. J., Lewis, H. W., & Way, E. C. (2009). Concepts and fuzzy sets: Misunderstandings, misconceptions, and oversights. *International Journal of Approximate Reasoning, 51*(1), 23-34. doi: 10.1016/j.ijar.2009.06.012

Bendall, S. , Jackson, H. J. , Hulbert, C. A., & McGorry, P. D. . (2008). Childhood trauma and psychotic disorders: a systematic, critical review of the evidence. *Schizophrenia Bulletin, 34*(3), 568-579. doi: 10.1093/schbul/sbm121

Berenbaum, H., Kerns, J. G., Vernon, L. L., & Gomez, J. J. (2008). Cognitive correlates of schizophrenia signs and symptoms: I. verbal communication disturbances. *Psychiatry Research, 159*(1-2), 147-156. doi: 10.1016/j.psychres.2007.08.016

Berenbaum, H., Oltmanns, T. F., & Gottesman, I. I. (1985). Formal thought disorder in schizophrenics and their twins. *Journal of Abnormal Psychology, 94*(1), 3-16. doi: 10.1037//0021-843X.94.1.3

Bird, C. M., & Cipolotti, L. (2007). The utility of the recognition memory test and the graded naming test for monitoring neurological patients. *British Journal of Clinical Psychology, 46*(2), 223-234. doi: 10.1348/014466506x150282

Bird, C. M., Papadopoulou, K., Ricciardelli, P., Rossor, M. N., & Cipolotti, L. (2004). Monitoring cognitive changes: psychometric properties of six cognitive tests. *British Journal of Clinical Psychology, 43*(2), 197-210. doi: 10.1348/014466504323088051

Bradley, M. M., & Lang, P. J. (1999). *Affective norms for English words (ANEW): Instruction manual and affective ratings*: The Center for Research in Psychophysiology, University of Florida.

Brady, D. I., Schwean, V. L., Saklofske, D. H., McCrimmon, A. W., Montgomery, J. M., & Thorne, K. J. (2013). Conceptual and perceptual set-shifting executive abilities in young adults with Asperger's syndrome. *Research in Autism Spectrum Disorders, 7*(12), 1631-1637. doi: 10.1016/j.rasd.2013.09.009

Buda, M., Fornito, A., Bergström, Z. M., & Simons, J. S. (2011). A specific brain structural basis for individual differences in reality monitoring. *The Journal of Neuroscience, 31*(40), 14308-14313. doi: 10.1523/jneurosci.3595-11.2011

Casey, P. J., & Heath, R. A. (1988). Category norms for Australians. *Australian Journal of Psychology, 40*(3), 323-339. doi: 10.1080/00049538808260053

Chapman, J., & McGhie, A. (1962). A comparative study of disordered attention in schizophrenia. *Journal of Mental Science, 108*(455), 487-500. doi: 10.1192/bjp.108.455.487

Coleman, M. J., Levy, D. L., Lenzenweger, M. F., & Holzman, P. S. (1996). Thought disorder, perceptual aberrations, and schizotypy. *Journal of Abnormal Psychology, 105*(3), 469-473. doi: 10.1037/0021-843X.105.3.469

Connolly, A. J., Cobb-Richardson, P., & Ball, S. A. (2008). Personality disorders in homeless drop-in center clients. *Journal of Personality Disorders, 22*(6), 573-588. doi: 10.1521/pedi.2008.22.6.573

Costello, A. L., & Warrington, E. K. (1989). Dynamic aphasia: the selective impairment of verbal planning. *Cortex, 25*(1), 103-114. doi: 10.1016/S0010-9452(89)80010-3

Crawford, J., Cayley, C., Lovibond, P. F., Wilson, P. H., & Hartley, C. (2011). Percentile norms and accompanying interval estimates from an Australian general adult population sample for self-report mood scales (BAI, BDI, CRSD, CES-D, DASS, DASS-21, STAI-X, STAI-Y, SRDS, and SRAS). *Australian Psychologist, 46*(1), 3-14. doi: 10.1111/j.1742-9544.2010.00003.x

Cuesta, M. J., & Peralta, V. (1999). Thought disorder in schizophrenia. Testing models through confirmatory factor analysis. *European Archives of Psychiatry and Clinical Neuroscience, 249*(2), 55-61. doi: 10.1007/s004060050066

Cuesta, M. J., & Peralta, V. (2011). Testing the hypothesis that formal thought disorders are severe mood disorders. *Schizophrenia Bulletin, 37*(6), 1136-1146. doi: 10.1093/schbul/sbr092

Czermak, C., Lehofer, M., Gasser-Steiner, P., Ettinger, S., Lemonis, L., Rohrhofer, A. ..., & Liebmann, P. M. (2005). Test-retest reliability of a lifetime drug use questionnaire. *Addictive Behaviours, 30*(2), 361-368. doi: 10.1016/j.addbeh.2004.05.005

Davidoff, J., & Roberson, D. (2004). Preserved thematic and impaired taxonomic categorisation: A case study. *Language and Cognitive Processes, 19*(1), 137-174. doi: 10.1080/01690960344000125

Davis, G. C., Simpsom, D. M., Foster, D., Arison, Z., & Post, M. (1986). Reliability of Andreasen's thought, language, and communications disorder scale. *Hillside Journal of Clinical Psychiatry, 8*(1), 25-33. Retrieved from http://psycnet.apa.org

Delis, D. C., Kaplan, E., & Kramer, J. H. (2001a). *Delis-Kaplan Executive Function System (D-KEFS) examiner's manual*. San Antonio, Texas: The Psychological Corporation.

Delis, D. C., Kaplan, E., & Kramer, J. H. (2001b). *Delis-Kaplan Executive Function System: Technical manual*. San Antonio, Texas: The Psychological Corporation.

Delis, D. C., Kramer, J. H., Kaplan, E., & Ober, B. A. (2000). *California Verbal Learning Test Second Edition: Adult Version*. San Antonio: Pearson.

Demjaha, A., Valmaggia, L., Stahl, D., Byrne, M., & McGuire, P. (2012). Disorganization/cognitive and negative symptom dimensions in the at-risk mental state predict subsequent transition to psychosis. *Schizophrenia Bulletin, 38*(2), 351-359. doi: 10.1093/schbul/sbq088

DeVylder, J. E., Muchomba, F. M., Gill, K. E., Ben-Davida, S., Walder, D. J., Malaspina, D., & Corcoran, C. M. (2014). Symptom trajectories and psychosis onset in a clinical high-risk cohort: The relevance of subthreshold thought disorder. *Schizophrenia Research, 159*(2-3), 278-283. doi: 10.1016/j.schres.2014.08.008

Docherty, N. M. (1993). Communication deviance, attention, and schizotypy in parents of schizophrenic patients. *The Journal of Nervous and Mental Disease, 181*(12), 750-756. doi: 10.1097/00005053-199312000-00007

Dunn, L. M., & Dunn, D. M. (2007). Peabody Picture Vocabulary Test- Fourth Edition. Minneapolis, MN: Pearson Education, Inc.

Ettinger, U., Meyhöfer, I., Steffens, M., Wagner, M., & Koutsouleris, N. (2014). Genetics, cognition, and neurobiology of schizotypal personality: a review of the overlap with

schizophrenia. *Frontiers in Psychiatry*. doi: Advance online publication. doi: 10.3389/fpsyt.2014.00018

Faul, F., Erdfelder, E., Buchner, A., & Lang, A. -G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods, 41*(4), 1149-1160. Retrieved from http://www.gpower.hhu.de

Fonseca-Pedrero, E., Lemos-Giráldez, S., Paino, M., Sierra-Baigrie, S., & Muñiz, J. (2012). Relationship between schizotypal and borderline traits in college students. *The Spanish Journal of Psychology, 15*(1), 306-314. doi: 10.5209/rev_SJOP.2012.v15.n1.37337

Fulford, D., Feldman, G., Tabak, B. A., McGillicuddy, M., & Johnson, S. L. (2013). Positive affect enhances the association of hypomanic personality and cognitive flexibility. *International Journal of Cognitive Therapy, 6*(1), 1-16. doi: 10.1521/ijct.2013.6.1.1

Furnham, A., Batey, M., Anand, K., & Manfield, J. (2008). Personality, hypomania, intelligence and creativity. *Personality and Individual Differences, 44*(5), 1060–1069. doi: 10.1016/j.paid.2007.10.035

Gale, C. R., Batty, G. D., McIntosh, A. M., Porteous, D. J., Deary, I. J., & Rasmussen, F. (2013). Is bipolar disorder more common in highly intelligent people? A cohort study of a million men. *Molecular Psychiatry, 18*(2), 190-194. doi: 10.1038/mp.2012.26

Gard, D., Harrell, E. H., & Poreh, A. (1999). Cognitive deficits in schizophrenia on the WAIS-R NI Sentence Arrangement subtest. *Journal of Clinical Psychology, 55*(9), 1085-1094. doi: 10.1002/(SICI)1097-4679(199909)55:9<1085::AID-JCLP6>3.0.CO;2-G

Gau, S. S., & Huang, W. L. (2014). Rapid visual information processing as a cognitive endophenotype of attention deficit hyperactivity disorder. *Psychological Medicine, 44*(2), 435-446. doi: 10.1017/S0033291713000640

Gooding, D. C., Tallent, K. A., & Hegyi, J. V. (2001). Cognitive slippage in schizotypic individuals. *The Journal of Nervous and Mental Disease, 189*(11), 750-756. doi: 10.1097/00005053-200111000-00004

Gossop, M., Darke, S., P., Griffiths, Hando, J., Powis, B., Hall, W., & Strang, J. (1995). The Severity of Dependence Scale (SDS): psychometric properties of the SDS in English and Australian samples of heroin, cocaine and amphetamine users. *Addiction, 90*(5), 607-614. doi: 10.1046/j.1360-0443.1995.9056072.x

Gras, A., Amad, A., Thomas, P., & Jardri, R. (2014). Hallucinations and borderline personality disorder: a review. *Encephale, 40*(6), 431-438. doi: 10.1016/j.encep.2014.07.002

Harrow, M., Green, K. E., Sands, J. R., Jobe, T. H., Goldberg, J. F., Kaplan, K. J., & Martin, E. M. (2000). Thought disorder in schizophrenia and mania: impaired context. *Schizophrenia Bulletin, 26*(4), 879-891. Retrieved from http://psycnet.apa.org

Harvey, P. D. (1985). Reality monitoring in mania and schizophrenia: the association of thought disorder and performance. *Journal of Nervous and Mental Disease, 173*(2), 67-73. doi: 10.1097/00005053-198502000-00001

Harvey, P. D., Earle-Boyer, E. A., & Levinson, J. C. (1988). Cognitive deficits and thought disorder: a retest study. *Schizophrenia Bulletin, 14*(1), 57-66. Retrieved from http://europepmc.org

Harvey, P. D., Earle-Boyer, E. A., & Wielgus, M. S. (1984). The consistency of thought disorder in mania and schizophrenia. An assessment of acute psychotics. *Journal of Nervous and Mental Disease, 172*(8), 458-463. doi: 10.1097/00005053-198408000-00003

Harvey, P. D., Lenzenweger, M. F., Keefe, R. S. E., Pogge, D. L., Serper, M. R., & Mohs, R. C. (1992). Empirical assessment of the factorial structure of clinical symptoms in

schizophrenic patients: formal thought disorder. *Psychiatry Research, 44*(2), 141-151. doi: 10.1016/0165-1781(92)90048-8

Harvey, P. D., & Pedley, M. (1989). Auditory and visual distractibility in schizophrenia: clinical and medication status correlations. *Schizophrenia Research, 2*(3), 295-300. doi: 10.1016/0920-9964(89)90006-6

Heaton, R. K. (1981). *Wisconsin card sorting test manual*. Odessa, Florida: Psychological Assessment Resources.

Henry, J., & Crawford, J. (2005). A meta-analytic review of verbal fluency deficits in schizophrenia relative to other neurocognitive deficits. *Cognitive Neuropsychiatry, 10*(1), 1-33. doi: 10.1080/13546800344000309

Hilti, C., Delko, T., Orosz, A. T., Thomann, K., Ludewig, S., Geyer, M. A., . . . Cattapan-Ludewig, K. (2010). Sustained attention and planning deficits but intact attentional set-shifting in neuroleptic-naive first-episode schizophrenia patients. *Neuropsychobiology, 61*(2), 79-86. doi: 10.1159/000265133

Hjelmquist, E. K. E. (1989). Concept formation in non-verbal categorization tasks in brain-damaged patients with and without aphasia. *Scandinavian Journal of Psychology, 30*(4), 243-254. doi: 10.1111/j.1467-9450.1989.tb01087.x

Housden, C. R., Hermans, L. F, Sambeth, A., Verhaeg, A., Rock, P. L., Blackwell, A. D., & Nathan, P. J. (2014, October). *Development and validation of a concise cognitive assessment for use in phase 1 clinical trials*. Poster abstract presented at the meeting of ISCTM 2014 Autumn Conference in Boston, MA. Retrieved from https://isctm.org

Johnson, M. D., & Raye, C. L. (1981). Reality monitoring. *Psychological Review, 88*(1), 67-85. doi: 10.1037/0033-295X.88.1.67

Kaplan, E., Fein, D., Morris, R., & Delis, D. (1991). *WAIS-R NI manual: WAIS-R as a neuropsychological instrument*. Chicago: Psychological Corporation.

Kerns, J. G., & Becker, T. M. (2008). Communication disturbances, working memory, and emotion in people with elevated disorganized schizotypy. *Schizophrenia Research, 100*(1-3), 172-180. doi: 10.1016/j.schres.2007.11.005

Kerns, J. G., & Berenbaum, H. (2002). Cognitive impairments associated with formal thought disorder in people with schizophrenia. *Journal of Abnormal Psychology, 111*(2), 211-224. doi: 10.1037/0021-843X.111.2.211

Kertesz, A., & McCabe, P. (1975). Intelligence and aphasia: Performance of aphasics on Raven's coloured progressive matrices (RCPM). *Brain and Language, 2*(4), 387-395. doi: 10.1016/S0093-934X(75)80079-4

Kiang, M., & Kutas, M. (2006). Abnormal typicality of responses on a category fluency task in schizotypy. *Psychiatry Research, 145*(2-3), 119-126. doi: 10.1016/j.psychres.2005.12.010

Kim, H. S., An, Y. M., Kwon, J. S., & Shin, M. S. (2014). A preliminary validity study of the Cambridge Neuropsychological Test Automated Battery for the Assessment of Executive Function in Schizophrenia and Bipolar Disorder. *Psychiatry Investigation, 11*(4), 394-401. doi: 10.4306/pi.2014.11.4.394

Kwapil, T. R., Miller, M. B., Zinser, M. C., Chapman, L. J., Chapman, J., & Eckblad, M. (2000). A longitudinal study of high scorers on the Hypomanic Personality Scale. *Journal of Abnormal Psychology, 109*(2), 222-226. doi: 10.1037/0021-843x.109.2.222

Large, M., Sharma, S., Compton, M. T., Slade, T., & Nielssen, O. (2011). Cannabis use and earlier onset of psychosis: A systematic meta-analysis. *Archives of General Psychiatry, 68*(6), 555-561. doi: 10.1001/archgenpsychiatry.2011.5

Laws, K. R., Duncan, A., & Gale, T. M. (2010). 'Normal' semantic-phonemic fluency discrepancy in Alzheimer's disease? a meta-analytic study. *Cortex, 46*(5), 595-601. doi: 10.1016/j.cortex.2009.04.009

Lee, I. A., & Preacher, K. J. (2013). Calculation for the test of the difference between two dependent correlations with one variable in common [Computer software]. Retrieved from http://quantpsy.org

Lenhard, W., & Lenhard, A. (2015). Calculation of effect sizes. Retrieved from http://www.psychometrica.de

Lentz, V., Robinson, J., & Bolton, J. M. (2010). Childhood adversity, mental disorder comorbidity, and suicidal behavior in schizotypal personality disorder. *The Journal of Nervous and Mental Disease, 198*(11), 795-801. doi: 10.1097/NMD.0b013e3181f9804c

Lenzenweger, M. F. (2010). *Schizotypy and schizophrenia: the view from experimental psychopathology*. London: The Guilford Press.

Levaux, M. N., Potvin, S., Sepehry, A. A., Sablier, J., Mendrek, A., & Stip, E. (2007). Computerised assessment of cognition in schizophrenia: promises and pitfalls of CANTAB. *European Psychiatry, 22*(2), 104-115. doi: 10.1016/j.eurpsy.2006.11.004

Lezak, M. D. (1995). *Neuropsychological assessment* (3rd ed.). Oxford, England: Oxford University Press.

Lezak, M. D., Howieson, D. B., Bigler, E. D., & Tranel, D. (2012). *Neuropsychological assessment* (5 ed.). New York: Oxford University Press.

Lezak, M. D., Howieson, D. B., & Loring, D. W. (2004). *Neuropsychological assessment* (4th ed.). Melbourne: Oxford University Press.

Liddle, P. F., Ngan, E. T. C., Caissie, S. L., Anderson, C. M., Bates, A. T., Quested, D. J., . . . Weg, R. (2002). Thought and Language Index: an instrument for assessing thought

and language in schizophrenia. *British Journal of Psychiatry, 181*(4), 326-330. doi: 10.1192/bjp.181.4.326

Lovibond, S. H., & Lovibond, P. F. (1995). *Manual for the Depression Anxiety Stress Scales*. Sydney: Psychology Foundation.

Luciana, M. (2003). Practitioner review: computerized assessment of neuropsychological function in children: clinical and research applications of the Cambridge Neuropsychological Testing Automated Battery (CANTAB). *Journal of Child Psychology and Psychiatry, 44*(5), 649-663. doi: 10.1111/1469-7610.00152

Lupyan, G., & Mirman, D. (2013). Linking language and categorization: evidence from aphasia. *Cortex, 49*(5), 1187-1194. doi: 10.1016/j.cortex.2012.06.006

Macare, C., Bates, T. C., Heath, A. C., Martin, N. G., & Ettinger, U. (2012). Substantial genetic overlap between schizotypy and neuroticism: a twin study. *Behavior genetics, 42*(5), 732-742. doi: 10.1007/s10519-012-9558-6

MacCabe, J. H., Lambe, M. P., Cnattingius, S., Sham, P. C., David, A. S., Reichenberg, A., . . . Hultman, C. M. (2010). Excellent school performance at age 16 and risk of adult bipolar disorder: national cohort study. *British Journal of Psychiatry, 196*(2), 109-115. doi: 10.1192/bjp.bp.108.060368

McDonald, J. H. (2009). *Handbook of biological statistics* (2nd ed.). Baltimore, Maryland, U.S.A.: Sparky House Publishing.

McGrath, J. (1991). Ordering thoughts on thought disorder. *British Journal of Psychiatry, 158*, 307-316. doi: 10.1192/bjp.158.3.307

Minor, K. S., & Cohen, A. S. (2010). Affective reactivity of speech disturbances in schizotypy. *Journal of Psychiatric Research, 44*(2), 99-105. doi: 10.1016/j.jpsychires.2009.06.005

Minor, K. S., Cohen, A. S., Weber, C. R., & Brown, L. A. (2011). The relationship between atypical semantic activation and odd speech in schizotypy across emotionally evocative conditions. *Schizophrenia Research, 126*(1-3), 144-149. doi: 10.1016/j.schres.2010.06.016

Mitchell, K. J., & Johnson, M. K. (2009). Source monitoring 15 years later: what have we learned from fMRI about the neural mechanisms of source memory? *Psychological Bulletin, 135*(4), 638-677. doi: 10.1037/a0015849

Mungas, D., Reed, B. R., Farias, S. T., & DeCarli, C. (2009). Age and education effects on relationships of cognitive test scores with brain structure in demographically diverse older persons. *Psychology and Aging, 24*(1), 116-128. doi: 10.1037/a0013421

Murray, H. A. (1943). *Thematic Apperception Test manual*.

Nagels, A., Stratmann, M., Ghazi, S., Schales, C., Frauenheim, M., Turner, L., . . . Kircher, T. T. (2013). The German translation and validation of the Scale for the Assessment of Thought, Language and Communication: A factor analytic study. *Psychopathology, 46*(6), 390-395. doi: 10.1159/000345359

Neill, E. (2014). Methodological considerations in the recruitment and analysis of schizotypy samples. *Frontiers in Psychiatry, 5*, 156. doi: 10.3389/fpsyt.2014.00156

Nelson, M. T., Seal, M. L., Pantelis, C., & Phillips, L. J. (2013). Evidence of a dimensional relationship between schizotypy and schizophrenia: A systematic review. *Neuroscience & Biobehavioral Reviews, 37*(3), 317-327. doi: 10.1016/j.neubiorev.2013.01.004

Oltmanns, T. F., & Neale, J. M. (1975). Schizophrenic performance when distractors are present: Attentional deficit or differential task difficulty. *Journal of Abnormal Psychology, 84*(3), 205-209. doi: 10.1037/h0076721

Ott, S. L., Roberts, S., Rock, D., Allen, J., & Erlenmeyer-Kimling, L. (2002). Positive and negative thought disorder and psychopathology in childhood among subjects with adulthood schizophrenia. *Schizophrenia Research, 58*(2-3), 231-239. doi: 10.1016/S0920-9964(01)00339-5

Owen, A. M., Downes, J. J., Sahakian, B. J., Polkey, C. E., & Robbins, T. W. (1990). Planning and spatial working memory following frontal lobe lesions in man. *Neuropsychologia, 28*(10), 1021-1034. doi: 10.1016/0028-3932(90)90137-D

Owen, A. M., Morris, R. G., Sahakian, B. J., Polkey, C. E., & Robbins, T. W. (1996). Double dissociations of memory and executive functions in working memory tasks following frontal lobe excisions, temporal lobe excisions or amygdalo-hippocampectomy in man. *Brain, 119*(5), 1597-1615. doi: 10.1093/brain/119.5.1597

Paulsen, J. S., Heaton, R. K., Sadek, J. R., Perry, W., Delis, D. C., Braff, D., . . . Jeste, D. V. (1995). The nature of learning and memory impairments in schizophrenia. *Journal of the International Neuropsychological Society, 1*(1), 88-99. doi: 10.1017/S135561770000014X

Peralta, V., Cuesta, M. J., & De Leon, J. (1992). Formal thought disorder in schizophrenia: a factor analytic study. *Comprehensive Psychiatry, 33*(2), 105-110. doi: 10.1016/0010-440X(92)90005-B

Persons, J. B. (1986). The advantages of studying psychological phenomena rather than psychiatric diagnoses. *American Psychologist, 41*(11), 1252-1260. doi: 10.1037/0003-066X.41.11.1252

Persons, J. B., & Baron, J. (1985). Processes underlying formal thought disorder in psychiatric inpatients. *The Journal of Nervous and Mental Disease, 173*(11), 667-676.

Peterson, R. A. (2001). On the use of college students in social science research: Insights from a second-order meta-analysis. *Journal of Consumer Research, 28*(3), 450-461. doi: 10.1086/323732

Poreh, A. M., Rawlings, D., Claridge, G., Freeman, J. L., Faulkner, C., & Shelton, C. (2006). The BPQ: A Scale for the Assessment of Borderline Personality Based on DSM-IV Criteria. *Journal of Personality Disorders, 20*(3), 247-260. doi: 10.1521/pedi.2006.20.3.247

Rabin, L. A., Barr, W. B., & Burton, L. A. (2005). Assessment practices of clinical neuropsychologists in the United States and Canada: A survey of INS, NAN, and APA Division 40 members. *Archives of Clinical Neuropsychology, 20*(1), 33-65. doi: 10.1016/j.acn.2004.02.005

Raine, A. (1991). The SPQ: A scale for the assessment of schizotypal personality based on DSM-III-R criteria. *Schizophrenia Bulletin, 17*(4), 556-564. Retrieved from http://europepmc.org

Raine, A., & Lencz, T. (1995). Conceptual and theoretical issues in schizotypal personality research. In A. Raine, T. Lencz & S. A. Mednick (Eds.), *Schizotypal personality* (pp. 3-15). Cambridge: Cambridge University Press.

Read, J., Fosse, R., Moskowitz, A., & Perry, B. (2014). The traumagenic neurodevelopmental model of psychosis revisited. *Neuropsychiatry, 4*(1), 65-79. doi: 10.2217/npy.13.89

Reitan, R. M., & Wolfson, D. (1985). *The Halstead-Reitan neuropsychological test battery: theory and clinical interpretation*. Tucson, Arizona: Neuropsychology Press.

Remberk, B., Namyslowska, I., & Rybakowski, F. (2012). Clinical and cognitive correlates of formal thought disorder in early onset schizophrenia. *Activitas Nervosa Superior Rediviva, 54*(2), 68-76. Retrieved from http://europepmc.org

Robbins, T. W., James, M., Owen, A. M., Sahakian, B. J., Lawrence, A. D., McInnes, L., & Rabbitt, P. M. A. (1998). A study of performance on tests from the CANTAB battery sensitive to frontal lobe dysfunction in a large sample of normal volunteers: implications for theories of executive functioning and cognitive aging. *Journal of the International Neuropsychological Society, 4*(5), 474-490. doi: 10.1017/S1355617798455073

Roberts, P. M. (2003). Performance of Canadian adults on the Graded Naming Test. [Article]. *Aphasiology, 17*(10), 933-946. doi: 10.1080/02687030344000300

Rosvold, H. E., Mirsky, A. F., Sarason, I., Bransome Jr., E. D., & Beck, L. H. (1956). A continuous performance test of brain damage. *Journal of Consulting Psychology, 20*(5), 343-350. doi: org/10.1037/h0043220

Sahakian, B. J., & Owen, A. M. (1992). Computerized assessment in neuropsychiatry using CANTAB: discussion paper. *Journal of the Royal Society of Medicine, 85*(7), 399-402. doi: 10.1177/014107689208500711

Sanchez-Cubillo, I., Perianez, J. A., Adrover-Roig, D., Rodriguez-Sanchez, J. M., Rios-Lago, M., Tirapu, J., & Barcelo, F. (2009). Construct validity of the Trail Making Test: role of task-switching, working memory, inhibition/interference control, and visuomotor abilities. *Journal of the International Neuropsychological Society, 15*(3), 438-450. doi: 10.1017/S1355617709090626

Sans-Sansa, B., McKenna, P. J., Canales-Rodriguez, E. J., Ortiz-Gil, J., Lopez-Araquistain, L. L., Sarro, S., . . . Pomarol-Clotet, E. (2013). Association of formal thought disorder in schizophrenia with structural brain abnormalities in language-related cortical regions. *Schizophrenia Research, 146*(1-3), 308-313. doi: 10.1016/j.schres.2013.02.032

Scott, R. B., Harrison, J., Boulton, C., Wilson, J., Gregory, R., Parkin, S., . . . Aziz, T. Z. (2002). Global attentional–executive sequelae following surgical lesions to globus pallidus interna. *Brain, 125*(3), 562-574. doi: 10.1093/brain/awf046

Shallice, T. (1982). Specific impairments in planning. *Philosophical Transactions of the Royal Society of London, 298*(1089), 199-209. doi: 10.1098/rstb.1982.0082

Shao, Z., Janse, E., Visser, K., & Meyer, A. (2014). What do verbal fluency tasks measure? Predictors of verbal fluency performance in older adults. *Frontiers in Psychology, 5*(772). doi: 10.3389/fpsyg.2014.00772

Smith, P. J., Need, A. C., Cirulli, E. T., Chiba-Falek, O., & Attix, D. K. (2013). A comparison of the Cambridge Automated Neuropsychological Test Battery (CANTAB) with "traditional" neuropsychological testing instruments. *Journal of Clinical and Experimental Neuropsychology, 35*(3), 319-328. doi: 10.1080/13803395.2013.771618

Steiger, J. H. (1980). Tests for comparing elements of a correlation matrix. *Psychological Bulletin, 87*(2), 245-251. doi: 10.1037/0033-2909.87.2.245

Stirling, J., Hellewell, J., Blakeley, A., & Deakin, W. (2006). Thought disorder in schizophrenia is associated with both executive dysfunction and circumscribed impairments in semantic function. *Psychological Medicine, 36*(4), 475-484. doi: 10.1017/S0033291705006884

Stone, J. M., Fisher, H. L., Major, B., Chisholm, B., Woolley, J., Lawrence, J., . . . Young, A. H. (2014). Cannabis use and first-episode psychosis: relationship with manic and psychotic symptoms, and with age at presentation. *Psychological Medicine, 44*(3), 499–506. doi: 10.1017/S0033291713000883

Strauss, E., Sherman, E. M. S., & Spreen, O. (2006). *A compendium of neuropsychological tests* (3rd ed.). New York: Oxford University Press.

Stringaris, A., Castellanos-Ryan, N., Banaschewski, T., Barker, G. J., Bokde, A. L., Bromberg, U., . . . Conrod, P. (2014). Dimensions of manic symptoms in youth: psychosocial impairment and cognitive performance in the IMAGEN sample. *Journal of Child Psychology and Psychiatry, and Allied Disciplines, 55*(12), 1380-1389. doi: 10.1111/jcpp.12255

Stroop, J. R. (1935). Studies of interference in serial verbal reation. *Journal of Experimental Psychology, 18*(6), 643-662. doi: 10.1037/h0054651

Tan, E. J., & Rossell, S. L. (2014). Building a neurocognitive profile of thought disorder in schizophrenia using a standardized test battery. *Schizophrenia Research, 152*(1), 242-245. doi: 10.1016/j.schres.2013.11.001

Taylor, M. A., Reed, R., & Berenbaum, S. (1994). Patterns of speech disorders in schizophrenia and mania. *Journal of Nervous and Mental Disease, 182*(6), 319-326. doi: 10.1097/00005053-199406000-00002

Thorndike, R., & Lorge, I. (1944). *The teachers word book of 10,000 words*. New York: Columbia University Press.

Tombaugh, T. N. (1996). Test of Memory Malingering (TOMM). New York, NY: Multi-Health Systems, Inc.

Uhlhaas, P. J., Silverstein, S. M., Phillips, W. A., & Lovell, P. G. (2004). Evidence for impaired visual context processing in schizotypy with thought disorder. *Schizophrenia Research, 68*(2-3), 249-260. doi: 10.1016/S0920-9964(03)00184-1

Uitenbroek, D. G. (1997). SISA Binomial. Retrieved from http://www.quantitativeskills.com

van Os, J., Linscott, R. J., Myin-Germeys, L., Delespaul, P., & Krabbendam, L. (2009). A systematic review and meta-analysis of the psychosis continuum: evidence for a psychosis proneness-persistence-impairment model of psychotic disorder. *Psychological Medicine, 39*(2), 179-195. doi: 10.1017/S0033291708003814

Varese, F., Smeets, F., Drukker, M., Lieverse, R., Lataster, T., Viechtbauer, W., . . . Bentall, R. P. (2012). Childhood adversities increase the risk of psychosis: a meta-analysis of patient-control, prospective- and cross-sectional cohort studies. *Schizophrenia Bulletin, 38*(4), 661-671. doi: 10.1093/schbul/sbs050

Velikonja, T., Fisher, H. L., Mason, O., & Johnson, S. (2015). Childhood trauma and schizotypy: a systematic literature review. *Psychological Medicine, 45*(5), 947-963. doi: 10.1017/S0033291714002086

Walker, E., & Harvey, P. D. (1986). Positive and negative symptoms in schizophrenia: attentional performance correlates. *Psychopathology*, *19*(6), 294-302. doi: 10.1159/000284452

Wechsler, D. (1997). *Wechsler Adult Intelligence Scale-Third Edition*. San Antonio, TX: Psychological Corporation.

Wechsler, D. (2008). *Wechsler Adult Intelligence Scale-Fourth Edition: Technical and interpretive manual*. San Antonio, TX: Pearson.

Weinstein, S., McKay, R., & Ngan, E. T. (2008). Positive schizotypy is not associated with speech abnormality. *Early Intervention in Psychiatry*, *2*(2), 98-102. doi: 10.1111/j.1751-7893.2008.00064.x

Wilcox, J., Briones, D., Quadri, S., & Tsuang, M. (2014). Prognostic implications of paranoia and thought disorder in new onset psychosis. *Comprehensive Psychiatry*, *55*(4), 813-817. doi: 10.1016/j.comppsych.2013.12.010

Appendix

Table A1

Sample Demographic, Clinical and Cognitive Characteristics (N = 91)

Characteristic	*Md*	range	*M (SD)*	95% *CI* of *M*
Demographic				
Age (years)	20	16 – 25	20.1 (2.2)	19.6 – 20.6
Education (years)	10	7 – 15	10.0 (1.4)	9.8 – 10.3
Clinical				
Schizotypal Personality Questionnaire-Total	36	0 – 72	34.8 (15.3)	31.6 – 37.9
Borderline Personality Questionnaire-Total	36	4 – 68	34.5 (17.0)	30.9 – 38.0
Cognitive				
IQ				
Peabody Picture Vocabulary Test-IV (age Standard Score)	94	74 – 123	94.8 (10.9)	92.5 – 97.0
Matrix Reasoning SS	10	4 – 14	10.0 (2.5)	9.2 – 10.2
Attention/Processing speed				
Digit Span Forward-Total*	9	4 – 14	9.3 (1.9)	8.9 – 9.7
Digit Span Forward-SS	8	2 – 15	8.5 (2.5)	7.9 – 9.0
CVLT-II Trial 1-Total*	5	3 – 11	5.7 (2.0)	5.3 – 6.1
Rapid Visual Information Processing-A′*	0.9	0.7 – 1.0	0.9 (0.1)	0.9 – 0.9
Rapid Visual Information Processing-A′ (*SD* from *M*)	-0.5	-0.8 – -0.4	-0.6 (1.0)	-3.6 – 1.2
Auditory Digit Span Distractibility Test-distractible proportion*	0.9	0.3 – 1.0	0.9 (0.1)	0.8 – 0.9
Auditory Digit Span Distractibility Test-distractible intrusions*	1	0 – 8	1.7 (1.5)	1.4 – 2.0
Reaction Time-reaction time* (100ms)	2.8	2.0 – 5.3	2.9 (0.5)	2.8 – 3.0
Trail Making Test-A-Total* (s)	28	12 – 60	28.4 (9.2)	26.5 – 30.4
C-WIT-Colour Naming-Total* (s)	30	19 – 45	30.7 (6.0)	29.5 – 32.0
C-WIT-Colour Naming-SS	9	3 – 14	8.6 (2.7)	8.0 – 9.2
C-WIT-Word Reading-Total* (s)	22	15 – 51	23.5 (6.7)	22.1 – 24.9

Memory				
CVLT-II-short-delay free recall-Total*	11	2 – 15	10.7 (2.9)	10.1 – 11.3
CVLT-II-long-delay free recall-Total*	12	2 – 16	11.0 (2.9)	10.4 – 11.6
CVLT-II-long-delay free recall (*SD* from *M*)	0.0	-4.0 – 1.5	-0.4 (1.1)	-0.6 – -0.2
Paired Associates Learning-total trials adjusted*	8	5 – 32	9.4 (4.3)	8.5 – 10.3
Paired Associates Learning-total errors 8-shapes adjusted*	7	0 – 70	10.5 (12.3)	8.0 – 13.1
Language/Semantic				
Graded Naming Test-Total*	14	5 – 23	14.1 (4.3)	13.2 – 15.0
Graded Naming Test-SS	-1.5	-3.5 – 0.5	-1.5 (1.0)	-1.7 – -1.3
Typicality-first fruit category*	57.6	0.0 – 57.6	35.8 (25.6)	30.4 – 41.1
Typicality-first clothing category*	2.4	0.0 – 22.9	5.8 (7.9)	4.2 – 7.5
Category Fluency Test-Total*	56	36 – 84	56.7 (10.8)	54.5 – 58.9
Executive function/Higher-order reasoning abilities				
Picture Arrangement-Total*	14	3 – 22	14.0 (4.0)	13.1 – 14.8
Picture Arrangement-SS	9	4 – 19	9.4 (2.8)	8.8 – 10.0
Sentence Arrangement-Total	10	0 – 20	9.9 (5.2)	8.8 – 11.0
Sentence Arrangement-shift*	6	0 – 14	6.9 (4.2)	6.0 – 7.7
SWM-within errors*	0	0 – 9	1.3 (2.0)	0.9 – 1.7
SWM-between errors*	20	0 – 80	23.7 (16.2)	20.6 – 27.1
SWM-between errors 8 Boxes (*SD* from *M*)	0.5	-1.7 – 1.6	0.4 (0.7)	0.3 – 0.6
SWM-strategy*	33	18 – 42	31.9 (5.0)	30.9 – 32.9
SWM-strategy (*SD* from *M*)	0.2	-1.4 – 2.7	0.3 (0.8)	0.2 – 0.5
Intra-extradimensional Set Shift-block-8 errors*	7	0 – 32	11.3 (9.5)	9.3 – 13.3
Stockings of Cambridge-Perfect Solutions*	9	3 – 12	8.6 (1.9)	8.2 – 9.0
Stockings of Cambridge-Mean Initial Planning Time* (s)	7.0	0.8 – 43.9	96.6 (85.8)	78.8 – 14.5
Stop Signal Test-Stop signal response time* (100ms)	1.5	0.8 – 3.4	1.6 (0.4)	1.5 – 1.7
CVLT-II-recall consistency*	83	54 – 98	81.0 (10.0)	78.9 – 83.1
C-WIT-Inhibition* (s)	56	34 – 108	55.6 (14.3)	52.6 – 58.6
C-WIT-Inhibition SS	9	1 – 14	9.0 (3.0)	8.0 – 9.2
Trail Making Test-B-Total* (s)	60	23 – 298	69.0 (36.6)	61.4 – 76.6
Letter Fluency Test-Total*	36	7 – 61	36.1 (10.2)	34.0 – 38.3

Letter Fluency Test-SS	10	1 – 18	10.2 (3.3)	9.5 – 10.9
Reality Monitoring Test-new-as-say*	0	0 – 7	0.8 (1.4)	0.5 – 1.3
Reality Monitoring Test-think-as-say*	2	0 – 6	1.8 (1.2)	1.5 – 2.0

Note. * raw data. The Schizotypal Personality Questionnaire is from Raine (1991); the Borderline Personality Questionnaire is from Poreh et al. (2006); the Peabody Picture Vocabulary Test-II is from Dunn and Dunn (2007); Matrix Reasoning and Digit Span Forward are from the WAIS-IV (Wechsler, 2008); the Auditory Digit Span Distractibility Test is from Oltmanns and Neale (1975); Trail Making Tests-A and -B are described in Lezak et al. (2004); the California Verbal Learning Test-II (CVLT-II) is from Delis et al. (2000); Picture Arrangement is from the WAIS-III (Wechsler, 1997); Sentence Arrangement is from the WAIS-R-NI (Kaplan, et al., 1991); from the Delis-Kaplan Executive Function System battery (Delis, et al., 2001b) are the Colour-Word Interference Test (C-WIT), and Letter and Category Fluency Tests; the Reality Monitoring Test is from Johnson and Raye (1981); and the following are from the Cambridge Neuropsychological Test Automated Battery eclipse version 3.0 schizophrenia battery (Sahakian & Owen, 1992): Reaction Time; Paired Associates Learning; Rapid Visual Information Processing-A′, Spatial Working Memory (SWM); Graded Naming Test; Intra-extradimensional Set Shift; Stockings of Cambridge; and Stop Signal Test. *Md* = Median; *M* = mean; *SD* = standard deviation; *CI of M* = Confidence Interval of the mean; *SD* from *M* = Standard Deviation from the normative mean reported by the test author; SS = Scaled Score.

General Discussion

Disturbances of the form of speech, or *formal thought disorder* (FTD), are characteristic of schizophrenia (American Psychiatric Association, 2013); and are distinguished from abnormalities of *content* of thought (e.g., delusions). Consequent to evidence linking cognitive dysfunction with FTD (Barch & Berenbaum, 1996; Berenbaum, Kerns, Vernon, & Gomez, 2008; Goldberg et al., 1998; Harvey, 1985; Harvey, Earle-Boyer, & Levinson, 1988; Harvey, Earle-Boyer, Wielgus, & Levinson, 1986; Harvey & Pedley, 1989; Harvey & Serper, 1990; Kerns & Berenbaum, 2002; McGrath, Scheldt, & Hengstberger, 1997; McGrath, Scheldt, Welham, & Clair, 1997; Stirling, Hellewell, Blakeley, & Deakin, 2006), there is a focus on developing cognitive models to explain FTD (Barch & Berenbaum, 1996, 1997; Berenbaum, et al., 2008; Goldberg, et al., 1998; Kiang, 2010; Levine, Schild, Kimhi, & Schreiber, 1996; McGrath, 1991; Mohr, Graves, Gianotti, Pizzagalli, & Brugger, 2001; Reilly, Harrow, Tucker, Quinlan, & Siegel, 1975; Rochester, 1978; Sommer, Dewar, Osmond, & Sask, 1960) and inform psychological intervention (Holshausen, 2012). But, progress has been limited by variability in findings, possibly due to patient-related confounds and differences across studies in whether associations were investigated using global measures of FTD (Stirling, et al., 2006) or subtypes of FTD (Barch & Berenbaum, 1996; Berenbaum, et al., 2008). Regarding the latter point, FTD is usually regarded as having *positive FTD* (PFTD) and *negative FTD* (NFTD) dimensions: however, the underlying structure may be more nuanced than a two factor structure, as factor analytic research reports two, and sometimes three primary factors in patients with schizophrenia (Andreasen, 1979; Andreasen & Grove, 1986; Andreou et al., 2008; Bazin, Lefrere, Passerieux, Sarfati, & Hardy-Bayle, 2002; Berenbaum, Oltmanns, & Gottesman, 1985; Cuesta & Peralta, 1999, 2011; Harvey et al., 1992; Nagels et al., 2013; Ott, Roberts, Rock, Allen, & Erlenmeyer-Kimling, 2002; Peralta, Cuesta, & De Leon, 1992; Taylor, Reed, &

Berenbaum, 1994). The *continuum approach* is free of patient-related confounds, as relationships of interest to schizophrenia symptoms are investigated in non-clinical samples with attenuated schizophrenia-like traits, or *schizotypal* traits (for discussion, see Persons, 1986); however, its suitability to FTD research is uncertain: Some evidence links elevated schizotypal traits with objectively-rated communication disturbance in undergraduate samples (Coleman, Levy, Lenzenweger, & Holzman, 1996; Minor & Cohen, 2010), but not all studies report this relationship (Weinstein, McKay, & Ngan, 2008). To our knowledge, no research has investigated the underlying dimensional structure of FTD in a general-community sample with psychometrically-elevated schizotypal traits, or examined cognitive relations with FTD dimensions in such a sample.

The broad aims of this investigation were to investigate the underlying dimensionality of FTD in a general-community sample with elevated schizotypal traits; and to examine the relationship between cognition and FTD in this sample. These aims were addressed using the continuum approach; and the methodology was informed by neuropsychological theory and praxis. Overall, it was expected that findings from this research would contribute to understanding the possible role of cognitive dysfunction in FTD.

Paper 1: "Formal Thought Disorder" in Homeless Young Adults with Elevated Schizotypal Traits: Underlying Dimensional Structure

The first paper examined levels of FTD in a general-community sample of young adults with elevated schizotypal traits to elucidate the underlying structure of FTD. The sample was recruited from two inner-city youth homeless services. FTD was indexed using the Scale for the Assessment of Thought, Language and Communication (TLC, Andreasen, 1978) and the Thought and Language Index (TLI, Liddle et al., 2002), as the sensitivity of the TLC to detect FTD in persons with elevated schizotypal traits is unknown; and the TLI is putatively a more sensitive index of FTD (Liddle, 1995). Using the TLC also facilitated comparison with

findings from clinical FTD research. Schizotypal traits were assayed using the Schizotypal Personality Questionnaire (SPQ; Raine, 1991). PCA was performed on ratings using both scales to investigate the structure of FTD; and provide FTD dimension scores for participants in Paper 2. We hypothesized that the sample would demonstrate elevated schizotypal traits and FTD; and that FTD would be associated with psychosis-like experiences. Also, we posited that PCA of the TLC and TLI would reveal two- or three-component solutions similar to those reported in patients with schizophrenia; and that conceptually-related TLC and TLI components would correlate. We also predicted that increasing severity of FTD would be related to general cognitive dysfunction, as indexed by IQ scores.

As expected, schizotypal traits were elevated for the sample, as measured using the SPQ and by clinical interview; and borderline traits were also elevated as indexed by the Borderline Personality Questionnaire (BPQ, Poreh et al., 2006). Of note, the sample demonstrated "clinically-elevated" communicative disturbances on the TLI; and more so using the TLC. As well, FTD in this sample was related to psychosis-like experiences: TLC Disorganisation and Emptiness components were linked specifically to psychosis-like experiences, indexed using measures from the SPQ and BPQ. With respect to the TLC, ratings generally approached, or were commensurate with ratings reported for patient groups with schizophrenia (Andreasen, 1979; Andreasen & Grove, 1986; Harvey, et al., 1992; Liddle, et al., 2002). However, *poverty of speech* assessed using the TLC was limited, possibly reflecting the relative absence of a sub-clinical "negative syndrome" characteristic of FTD as seen in chronic schizophrenia (Andreasen, 1979). Overall, the TLI provided less evidence of FTD than the TLC: However, the TLI appeared to more sensitively index *poverty of speech*, and this may relate to its more structured format (i.e., speech was rated while describing pictures) that better revealed those individuals who had more marked difficulty generating speech (even when provided with a focus).

PCA described a three-component TLC solution ("Disorganisation", "Verbosity", "Emptiness") which is generally consistent with schizophrenia research (for discussion, see Roche, Creed, MacMahon, Brennan, & Clarke, 2014); and a two-component TLI solution ("Negative", "Idiosyncratic"). Correlations between TLC and TLI dimensions were low however, likely reflecting differences in how the speech samples are elicited for each scale (interview versus describing pictures).

Our prediction that FTD would be related to general cognitive dysfunction was partially supported: increasing severity of TLI Negative was related to poorer verbal IQ and performance IQ; and similar directions of relationships were also seen between TLC Disorganisation and Emptiness scores and verbal IQ, although these were only at trend levels. An unexpected finding emerged between increasing severity on the TLC Verbosity component and ***stronger*** verbal IQ. The reason for this association is unclear, but we speculated that this may relate to hypomanic traits in some of our sample, possibly reflecting a degree of affective dysregulation (for discussion, see Kwapil et al., 2000); and hypomanic traits have been associated with schizotypal traits and psychosis-like experiences (Kwapil, et al.; Macare, Bates, Heath, Martin, & Ettinger, 2012). As well, hypomanic traits in general community samples have been associated with better functioning, including higher verbal IQ (Ford, Goodman, & Meltzer, 2003), fewer self-reported peer problems (Holtmann et al., 2009), divergent thinking and creativity (Furnham, Batey, Anand, & Manfield, 2008), and cognitive flexibility (Fulford, Feldman, Tabak, McGillicuddy, & Johnson, 2013).

Overall, the principal findings from this investigation include support for the conclusion that communicative disturbances are prominent in general-community samples with elevated schizotypal traits. Further to this, and importantly, a link was indicated between sub-clinical psychosis and FTD in this sample. Also supporting the continuum approach to FTD research, this investigation provided evidence demonstrating that FTD has a similar

underlying structure in general-community samples with elevated schizotypal traits as is reported in patients with schizophrenia (Andreasen, 1979; Andreasen & Grove, 1986; Andreou, et al., 2008; Bazin, et al., 2002; Berenbaum, et al., 1985; Cuesta & Peralta, 1999, 2011; Harvey, et al., 1992; Nagels, et al., 2013; Ott, et al., 2002; Peralta, et al., 1992; Taylor, et al., 1994). Our prediction that FTD would be related to general cognitive dysfunction was only partially supported; and an unexpected finding emerged between increasing severity on the TLC Verbosity component and stronger verbal IQ.

Paper 2: The Dimensional Nature of "Formal Thought Disorder" in Homeless Young Adults with Elevated Schizotypal Traits: Cognitive Correlates

The second paper investigated associations between dimensions of cognition and FTD using the continuum approach to inform understanding of the possible cognitive underpinnings of FTD and psychological therapies. Informing this investigation, Kerns and Berenbaum (2002) recommended neuropsychological investigation of different FTD subtypes, as some evidence indicates that subtypes of FTD are differentiated by different cognitive relationships (Barch & Berenbaum, 1996; Berenbaum, et al., 2008). Thus, we investigated the cognitive correlates of different dimensions of FTD using the sample from Paper 1. TLC and TLI dimension scores for each participant were derived from the PCA analysis in Paper 1. The neuropsychological battery represented 14 domains and subdomains of functioning. We had one general hypothesis: that significant relationships exist between dimensions of cognitive functioning and FTD in persons with elevated schizotypal traits. We made no prediction regarding the direction of relationships. Our secondary aim was to examine whether FTD dimensions were distinguished by different cognitive relationships. We also examined whether relationships between cognitive functioning and FTD were independent of demographic and clinical variables.

The findings supported our primary hypothesis: The post-hoc regression analysis indicated that higher-order reasoning, executive (set shift and generative ability), and language/semantic abilities were the likely drivers of FTD in our sample. TLI Negative was most strongly associated with a *combination* of impaired set shift and higher-order reasoning; and for TLC Disorganisation, these were a *combination* of higher-order reasoning and language/semantic dysfunction. Less strongly, though still significantly identified, TLI Idiosyncratic and TLC Emptiness were best predicted by language/semantic and higher-order reasoning dysfunction, respectively. In contrast, TLC Verbosity was related to *stronger* cognitive functioning: It was best predicted by stronger generative ability and language/semantic functioning. FTD in our sample was not related to generalized cognitive dysfunction. Overall, these findings linking dysfunction of higher-order reasoning, executive, and language/semantic abilities with increasing severity of FTD (as represented by TLC Disorganisation, TLC Emptiness, TLI Negative and TLI Idiosyncratic) accords with evidence reported in patients with schizophrenia (Kerns & Berenbaum, 2002).

The aim of investigating whether FTD dimensions were distinguished by different cognitive relationships was partially supported: TLC Verbosity was distinguished from the other FTD dimensions on most cognitive dimensions. However, it was not possible to *significantly* differentiate TLC Disorganisation, TLC Emptiness, TLI Negative and TLI Idiosyncratic from each other by their cognitive relationships. There was some evidence of a unique relationship between attentional dysfunction and NFTD.

An unanticipated relationship emerged between increasing severity of TLC Verbosity and *stronger* cognitive functioning. In Paper 1, a similar relationship emerged with verbal IQ. We are not aware of any similar finding in the literature; however, as described in Paper 1, we speculate that it may relate to hypomanic traits in our sample. One possibility is that the TLC Verbosity-cognitive relationships reported in our sample share some aetiology with

bipolar disorder. Perhaps the TLC Verbosity-cognitive relationships reported in our sample reflect the presence of a protective factor that mitigates against developing a clinical psychotic disorder in a subgroup of adolescents with elevated schizotypal and hypomanic traits. In line with this, in Paper 1, TLC Verbosity was unique among the TLC dimensions in not being associated with psychosis-like experiences.

Overall, in our sample, language/semantic and higher-order reasoning dysfunction appear to be the drivers of PFTD; while NFTD primarily relates to higher-order reasoning/executive dysfunction. These findings add to evidence indicating the importance of investigating cognitive relationships with different dimensions of FTD (Barch & Berenbaum, 1996; Berenbaum, et al., 2008). To the extent that the continuum hypothesis holds true, the results also provide convergent evidence associating executive dysfunction and impaired processing of semantic information with FTD in schizophrenia. The findings also support the utility of the continuum approach to neuropsychological FTD research.

Conclusion

In summary, Paper 1 was significant for demonstrating elevated communication disturbances in a general-community sample with schizotypal traits; and these disturbances had a multidimensional structure, similar to what has been reported in patients with schizophrenia (Andreasen, 1979; Andreasen & Grove, 1986; Andreou, et al., 2008; Bazin, et al., 2002; Berenbaum, et al., 1985; Cuesta & Peralta, 1999, 2011; Harvey, et al., 1992; Nagels, et al., 2013; Ott, et al., 2002; Peralta, et al., 1992; Taylor, et al., 1994). There was also evidence linking some dimensions of FTD with psychosis-like experiences, suggesting a possible link between FTD and sub-clinical psychosis in the sample. Paper 2 complemented Paper 1 by demonstrating that the FTD dimensions identified in Paper 1 were distinguishable by having different cognitive relationships; and some of these relationships resembled those reported in patients with schizophrenia. Overall, this evidence suggests the possibility that

FTD in our sample may share some common aetiology with FTD as it occurs in patients with schizophrenia. Both papers also revealed a relationship between stronger cognitive performance and increasing severity of verbosity-like disturbances. Further to this, different dimensions of FTD have been shown to differentiate patients with mania from patients with schizophrenia (Andreasen, 1979; Andreasen & Grove, 1986; Taylor, et al., 1994); and mania and schizophrenia are distinguishable by different patterns of relationships between cognitive functioning and FTD (Berenbaum, et al., 2008) and by course of FTD (for review, see Roche, et al., 2014).

Our research linking PFTD with language/semantic and higher-order reasoning dysfunction; and associating NFTD with higher-order reasoning/executive dysfunction generally accords with findings from imaging research that links FTD with smaller brain volume within the left posterior superior temporal lobe and frontal lobes in patients with schizophrenia (Horn et al., 2010; Horn et al., 2009; Rajarethinam, DeQuardo, Nalepa, & Tandon, 2000; Shenton et al., 1992; Subotnik, Bartzokis, Green, & Nuechterlein, 2003). This accordance is predicated on the understanding that the left temporal lobe and frontal lobes contribute to language/semantic abilities and higher-order reasoning/executive functions, respectively (Barbey et al., 2012; Price, 2012). In this regard, our findings provide converging evidence supporting preliminary findings from imaging research reporting differential patterns of volume reduction for different FTD subtypes: Sans-Sansa and colleagues (2013) reported that PFTD was negatively associated with left superior temporal gyrus and inferior operculum grey-matter volume; while NFTD (*poverty of content of speech*) was associated with medial frontal and orbitofrontal cortex volume bilaterally. This suggests the importance of examining brain structural and functional correlates of FTD subtypes to imaging research. An additional goal of future research includes accounting for FTD's variable course that may include remission, given that FTD has been posited to relate to brain

volume loss. One possibility is that perturbations of brain functioning (e.g. such as increased presynaptic striatal dopaminergic activity) may mediate or moderate some FTD-cognitive and FTD-brain structure relationships. For example, it has been suggested that severe and persistent disturbances of brain function may lead to volume reduction of language-related areas and FTD (Sans-Sansa, et al.).

We turn now to discussion of the relevance of the findings from the thesis to the nosology of schizophrenia-related FTD. The Diagnostic and Statistical Manual of Mental Disorders–Fifth Edition (DSM-V, American Psychiatric Association, 2013), like earlier versions of DSM, focuses primarily on disorganised speech as a characteristic symptom of schizophrenia, suggesting that this is a unitary construct, although mention is also made to 'alogia' as an example of negative symptoms. In contrast, the current research confirms the view that thought disorder comprises more than two dimensions, each underpinned by distinct cognitive profiles.

Regarding implications for clinical practice, given the associations reported in Paper 2 between increasing severity of FTD and cognitive dysfunction, it seems plausible that cognitive remediation may ameliorate FTD and assist functional recovery more broadly in patients with schizophrenia. This is partially predicated on meta-analytic research reporting small to moderate effects of cognitive remediation on cognitive functioning, psychosocial functioning, and symptoms in patients with schizophrenia (McGurk, Twamley, Sitzer, McHugo, & Mueser, 2007; Wykes, Huddy, Cellard, McGurk, & Czobor, 2011): This evidence has been reviewed (Katsumi, Hoshino, Fujimoto, & Niwa, 2015). However, we are unaware of research investigating cognitive remediation as a treatment for FTD (see also, Vita & De Peri, 2013). In contrast, preliminary evidence links treatment with operant conditioning (e.g., receiving gum or penny as contingent upon vocalizing) with increased speech output in patients with severe mutism (Baker, 1971; Isaacs, Thomas, & Goldiamond,

1960; Wilson & Walters, 1966); and therapy incorporating positive reinforcement and feedback have been linked with improvements with respect to goal-directedness and coherence of speech (Holshausen, 2012). The importance of developing effective psychological treatments for FTD is underscored by recent evidence demonstrating that while antipsychotic treatment reduces FTD severity in the short-term, in the longer term (e.g., at 10- and 20- year follow-up), patients receiving antipsychotic treatment have worse FTD and a much higher prevalence of psychosis than patients never prescribed antipsychotics (Harrow, Jobe, & Faull, 2014).

We turn now to discussion of the limitations and strengths of the studies. The use of two FTD rating scales permitted comparison across the scales, and facilitated comparison of the findings with previous research in schizophrenia. As well, cognitive relationships were investigated for each FTD dimension; the false discovery rate was well-controlled; and most cognitive dimensions were represented by composite scores. The neuropsychological battery was broad; and we investigated fine-grained subdomains of attention, semantic and executive function. On the basis of research describing elevated levels of schizotypal traits among homeless adults who are otherwise free of psychotic illness (Connolly, Cobb-Richardson, & Ball, 2008), we recruited our sample from youth homeless services. As anticipated, this strategy provided a sample with elevated schizotypal traits that was also free of DSM-V Axis I psychotic illness and confounds relating to antipsychotic medications and institutionalisation. Also, we felt that our sample was more representative of the psychosocial adversity one would expect of a sample hypothesised to fall on the schizophrenia spectrum than the typically used approach of recruiting highly-educated university students (for discussion, see all Lenzenweger, 2010; Minor, Cohen, Weber, & Brown, 2011; Neill, 2014; Raine & Lencz, 1995). However, our approach does limit what can be said about the generalisability of the results to a higher functioning general community sample with

elevated schizotypal traits. Also, given the unexpected relationship between TLC Verbosity and stronger cognitive functioning, a limitation of this investigation is that it did not include a measure of hypomanic traits. We also acknowledge as a possibility that other unmeasured constructs such as levels of autistic traits or developmental trauma may account for the observed FTD-cognitive relationships in our sample with elevated schizotypal traits.

Future research might consider using the continuum approach to further investigate the cognitive relationships with different dimensions of FTD: This might include using more sensitive measures of attention to investigate whether NFTD and PFTD can be distinguished by their relationships with attentional functioning. Along this line, relationships between FTD and semantic disorganisation could be explored in more depth than we were able, perhaps using more experimental measures. Also, the potential link that we described between hypomanic traits, FTD, and cognitive functioning may merit examination. Cognitive relationships with other forms of communication disturbance could also be investigated using the continuum approach: As a follow-up to this investigation, we are examining relationships between schizotypal traits, cognitive functioning, and intrusions of associations into speech.

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (5th ed.)*. Washington, DC: American Psychiatric Association.

Andreasen, N. (1978). *The Scale for the Assessment of Thought, Language and Communication (TLC)*. Iowa City: The University of Iowa.

Andreasen, N. (1979). Thought, language and communication disorders: II. Diagnostic significance. *Archives of General Psychiatry, 36*(12), 1325-1330. doi: 10.1001/archpsyc.1979.01780120055007

Andreasen, N., & Grove, W. M. (1986). Thought, language and communication in schizophrenia: Diagnosis and prognosis. *Schizophrenia Bulletin, 12*(3), 348-359. Retrieved from http://psycnet.apa.org

Andreou, C., Bozikas, V. P., Papouliakos, I., Kosmidis, M. H., Garyfallos, G., Kraravatos, A., & Nimatoudis, I. (2008). Factor structure of the Greek translation of the Scale for the Assessment of Thought, Language and Communication. *Australian and New Zealand Journal of Psychiatry, 2008*(42), 636-642. doi: 10.1080/00048670802119721

Baker, R. (1971). The use of operant conditioning to reinstate speech in mute schizophrenics. *Behaviour Research and Therapy, 9*(4), 329-336. doi: 10.1016/0005-7967(71)90045-3

Barbey, A. K., Colom, R., Solomon, J., Krueger, F., Forbes, C., & Grafman, J. (2012). An integrative architecture for general intelligence and executive function revealed by lesion mapping. *Brain: A Journal of Neurology, 135*(4), 1154-1164. doi: 10.1093/brain/aws021

Barch, D. M., & Berenbaum, H. (1996). Language production and thought disorder in schizophrenia. *Journal of Abnormal Psychology, 105*(1), 592-601. doi: 10.1037/0021-843X.105.1.81

Barch, D. M., & Berenbaum, H. (1997). The effect of language production manipulations on negative thought disorder and discourse coherence disturbances in schizophrenia. *Psychiatry Research, 71*(2), 115-127. doi: 10.1016/S0165-1781(97)00045-0

Bazin, N., Lefrere, F., Passerieux, C., Sarfati, Y., & Hardy-Bayle, M. C. (2002). Formal thought disorders: French translation of the Thought, Language and Communication assessment scale. *Encephale, 28*(2), 109-119. Retrieved from http://europepmc.org

Berenbaum, H., Kerns, J. G., Vernon, L. L., & Gomez, J. J. (2008). Cognitive correlates of schizophrenia signs and symptoms: I. verbal communication disturbances. *Psychiatry Research, 159*(1-2), 147-156. doi: 10.1016/j.psychres.2007.08.016

Berenbaum, H., Oltmanns, T. F., & Gottesman, I. I. (1985). Formal thought disorder in schizophrenics and their twins. *Journal of Abnormal Psychology, 94*(1), 3-16. doi: 10.1037//0021-843X.94.1.3

Coleman, M. J., Levy, D. L., Lenzenweger, M. F., & Holzman, P. S. (1996). Thought disorder, perceptual aberrations, and schizotypy. *Journal of Abnormal Psychology, 105*(3), 469-473. doi: 10.1037/0021-843X.105.3.469

Connolly, A. J., Cobb-Richardson, P., & Ball, S. A. (2008). Personality disorders in homeless drop-in center clients. *Journal of Personality Disorders, 22*(6), 573-588. doi: 10.1521/pedi.2008.22.6.573

Cuesta, M. J., & Peralta, V. (1999). Thought disorder in schizophrenia. Testing models through confirmatory factor analysis. *European Archives of Psychiatry and Clinical Neuroscience, 249*(2), 55-61. doi: 10.1007/s004060050066

Cuesta, M. J., & Peralta, V. (2011). Testing the hypothesis that formal thought disorders are severe mood disorders. *Schizophrenia Bulletin, 37*(6), 1136-1146. doi: 10.1093/schbul/sbr092

Ford, T., Goodman, R., & Meltzer, H. (2003). The British Child and Adolescent Mental Health Survey 1999: The prevalence of DSM-IV disorders. *Journal of the American Academy of Child and Adolescent Psychiatry, 42*(10), 1203-1211. doi: 10.1097/00004583-200310000-00011

Fulford, D., Feldman, G., Tabak, B. A., McGillicuddy, M., & Johnson, S. L. (2013). Positive affect enhances the association of hypomanic personality and cognitive flexibility. *International Journal of Cognitive Therapy, 6*(1), 1-16. doi: 10.1521/ijct.2013.6.1.1

Furnham, A., Batey, M., Anand, K., & Manfield, J. (2008). Personality, hypomania, intelligence and creativity. *Personality and Individual Differences, 44*(5), 1060–1069. doi: 10.1016/j.paid.2007.10.035

Goldberg, T. E., Aloia, M. S., Gourovitch, M. L., Missar, D., Pickar, D., & Weinberger, D. R. (1998). Cognitive substrates of thought disorder. I: the semantic system. *American Journal of Psychiatry, 155*(12), 1671-1676. doi: 10.1176/ajp.155.12.1671

Harrow, M., Jobe, T. H., & Faull, R. N. (2014). Does treatment of schizophrenia with antipsychotic medications eliminate or reduce psychosis? A 20-year multi-follow-up study. *Psychological Medicine, 44*(14), 3007-3016. doi: 10.1017/S0033291714000610

Harvey, P. D. (1985). Reality monitoring in mania and schizophrenia: the association of thought disorder and performance. *Journal of Nervous and Mental Disease, 173*(2), 67-73. doi: 10.1097/00005053-198502000-00001

Harvey, P. D., Earle-Boyer, E. A., & Levinson, J. C. (1988). Cognitive deficits and thought disorder: a retest study. *Schizophrenia Bulletin, 14*(1), 57-66. Retrieved from http://europepmc.org

Harvey, P. D., Earle-Boyer, E. A., Wielgus, M. S., & Levinson, J. C. (1986). Encoding, memory, and thought disorder in schizophrenia and mania. *Schizophrenia Bulletin, 12*(2), 252-261. doi: 10.1093/schbul/12.2.252

Harvey, P. D., Lenzenweger, M. F., Keefe, R. S. E., Pogge, D. L., Serper, M. R., & Mohs, R. C. (1992). Empirical assessment of the factorial structure of clinical symptoms in schizophrenic patients: formal thought disorder. *Psychiatry Research, 44*(2), 141-151. doi: 10.1016/0165-1781(92)90048-8

Harvey, P. D., & Pedley, M. (1989). Auditory and visual distractibility in schizophrenia: clinical and medication status correlations. *Schizophrenia Research, 2*(3), 295-300. doi: 10.1016/0920-9964(89)90006-6

Harvey, P. D., & Serper, M. R. (1990). Linguistic and cognitive failures in schizophrenia. A multivariate analysis. *Journal of Nervous and Mental Disease, 178*(8), 487-493. doi: 10.1097/00005053-199017880-00003

Holshausen, K. (2012). *Structured Therapy for the Enhancement of Purposeful Speech (STEPS): A Step in the Right Direction to Treating Formal Thought Disorder in Schizophrenia.* Queen's University, Kingston, Ont.

Holtmann, M., Pörtner, F., Duketis, E., Flechtner, H., Angst, J., & Lehmkuhl, G. (2009). Validation of the Hypomania Checklist (HCL-32) in a nonclinical sample of German adolescents. *Journal of Adolescence, 32*(5), 1075-1088. doi: 10.1016/j.adolescence.2009.03.004

Horn, H., Federspiel, A., Wirth, M., Müller, T. J., Wiest, R., Walther, S., & Strik, W. (2010). Gray matter volume differences specific to formal thought disorder in schizophrenia. *Psychiatry Research: Neuroimaging, 182*(2), 183-186. doi: 10.1016/j.pscychresns.2010.01.016

Horn, H., Federspiel, A., Wirth, M., Muller, T. J., Wiest, R., Wang, J., & Strik, W. (2009). Structural and metabolic changes in language areas linked to formal thought disorder. *The British Journal of Psychiatry, 194*(2), 130-138. doi: 10.1192/bjp.bp.107.045633

Isaacs, W., Thomas, J., & Goldiamond, I. (1960). Application of operant conditioning to reinstate verbal behavior in psychotics. *The Journal of Speech and Hearing Disorders, 25*, 8-12. doi: 10.1044/jshd.2501.08

Katsumi, A., Hoshino, H., Fujimoto, S., & Niwa, S. (2015). Efficacy of cognitive remediation in schizophrenia: A short review of its variable effects according to cognitive domain. . *Open Journal of Psychiatry, 5*, 170-176. doi: 10.4236/ojpsych.2015.52019.

Kerns, J. G., & Berenbaum, H. (2002). Cognitive impairments associated with formal thought disorder in people with schizophrenia. *Journal of Abnormal Psychology, 111*(2), 211-224. doi: 10.1037/0021-843X.111.2.211

Kiang, M. (2010). Schizotypy and language: A review. *Journal of Neurolinguistics, 23*(3), 193-203. Retrieved from http://www.sciencedirect.com

Kwapil, T. R., Miller, M. B., Zinser, M. C., Chapman, L. J., Chapman, J., & Eckblad, M. (2000). A longitudinal study of high scorers on the Hypomanic Personality Scale. *Journal of Abnormal Psychology, 109*(2), 222-226. doi: 10.1037/0021-843x.109.2.222

Lenzenweger, M. F. (2010). *Schizotypy and schizophrenia: the view from experimental psychopathology*. London: The Guilford Press.

Levine, J., Schild, K., Kimhi, R., & Schreiber, G. (1996). Word associative production in affective versus schizophrenic psychosis. *Psychopathology, 29*(1), 7-13. doi: 10.1159/000284966

Liddle, P. F. (1995). *Thought, Language, and Communication Index.* University of Vancouver, Vancouver, BC.

Liddle, P. F., Ngan, E. T. C., Caissie, S. L., Anderson, C. M., Bates, A. T., Quested, D. J., . . . Weg, R. (2002). Thought and Language Index: an instrument for assessing thought and language in schizophrenia. *British Journal of Psychiatry, 181*(4), 326-330. doi: 10.1192/bjp.181.4.326

Macare, C., Bates, T. C., Heath, A. C., Martin, N. G., & Ettinger, U. (2012). Substantial genetic overlap between schizotypy and neuroticism: a twin study. *Behavior genetics, 42*(5), 732-742. doi: 10.1007/s10519-012-9558-6

McGrath, J. (1991). Ordering thoughts on thought disorder. *British Journal of Psychiatry, 158*, 307-316. doi: 10.1192/bjp.158.3.307

McGrath, J., Scheldt, S., & Hengstberger, P. (1997). Thought disorder and executive ability. *Cognitive Neuropsychiatry, 2*(4), 303-314. doi: 10.1080/135468097396306

McGrath, J., Scheldt, S., Welham, J., & Clair, A. (1997). Performance on tests sensitive to impaired executive ability in schizophrenia, mania and well controls: acute and subacute phases. *Schizophrenia Research, 26*(2-3), 127-137. doi: 10.1016/S0920-9964(97)00070-4

McGurk, S. R., Twamley, E. W., Sitzer, D. I., McHugo, G. J., & Mueser, K. T. (2007). A meta-analysis of cognitive remediation in schizophrenia. *American Journal of Psychiatry, 164*(12), 1791-1802. doi: 10.1176/appi.ajp.2007.07060906

Minor, K. S., & Cohen, A. S. (2010). Affective reactivity of speech disturbances in schizotypy. *Journal of Psychiatric Research, 44*(2), 99-105. doi: 10.1016/j.jpsychires.2009.06.005

Minor, K. S., Cohen, A. S., Weber, C. R., & Brown, L. A. (2011). The relationship between atypical semantic activation and odd speech in schizotypy across emotionally evocative conditions. *Schizophrenia Research, 126*(1-3), 144-149. doi: 10.1016/j.schres.2010.06.016

Mohr, C., Graves, R. E., Gianotti, L. R., Pizzagalli, D., & Brugger, P. (2001). Loose but normal: a semantic association study. *Journal of Psycholinguistic Research, 30*(5), 475-483. doi: 10.1023/A:1010461429079

Nagels, A., Stratmann, M., Ghazi, S., Schales, C., Frauenheim, M., Turner, L., . . . Kircher, T. T. (2013). The German translation and validation of the Scale for the Assessment of Thought, Language and Communication: A factor analytic study. *Psychopathology, 46*(6), 390-395. doi: 10.1159/000345359

Neill, E. (2014). Methodological considerations in the recruitment and analysis of schizotypy samples. *Frontiers in Psychiatry, 5*, 156. doi: 10.3389/fpsyt.2014.00156

Ott, S. L., Roberts, S., Rock, D., Allen, J., & Erlenmeyer-Kimling, L. (2002). Positive and negative thought disorder and psychopathology in childhood among subjects with adulthood schizophrenia. *Schizophrenia Research, 58*(2-3), 231-239. doi: 10.1016/S0920-9964(01)00339-5

Peralta, V., Cuesta, M. J., & De Leon, J. (1992). Formal thought disorder in schizophrenia: a factor analytic study. *Comprehensive Psychiatry, 33*(2), 105-110. doi: 10.1016/0010-440X(92)90005-B

Persons, J. B. (1986). The advantages of studying psychological phenomena rather than psychiatric diagnoses. *American Psychologist, 41*(11), 1252-1260. doi: 10.1037/0003-066X.41.11.1252

Poreh, A. M., Rawlings, D., Claridge, G., Freeman, J. L., Faulkner, C., & Shelton, C. (2006). The BPQ: A Scale for the Assessment of Borderline Personality Based on DSM-IV Criteria. *Journal of Personality Disorders, 20*(3), 247-260. doi: 10.1521/pedi.2006.20.3.247

Price, C. J. (2012). A review and synthesis of the first 20 years of PET and fMRI studies of heard speech, spoken language and reading. *NeuroImage, 62*(2), 816-847. doi: 10.1016/j.neuroimage.2012.04.062

Raine, A. (1991). The SPQ: A scale for the assessment of schizotypal personality based on DSM-III-R criteria. *Schizophrenia Bulletin, 17*(4), 556-564. Retrieved from http://europepmc.org

Raine, A., & Lencz, T. (1995). Conceptual and theoretical issues in schizotypal personality research. In A. Raine, T. Lencz & S. A. Mednick (Eds.), *Schizotypal personality* (pp. 3-15). Cambridge: Cambridge University Press.

Rajarethinam, R. P., DeQuardo, J. R., Nalepa, R., & Tandon, R. (2000). Superior temporal gyrus in schizophrenia: a volumetric magnetic resonance imaging study. *Schizophrenia Research, 41*(2), 303-312. doi: 10.1016/S0920-9964(99)00083-3

Reilly, R., Harrow, M., Tucker, G. J., Quinlan, D., & Siegel, A. (1975). Looseness of associations in acute schizophrenia. *British Journal of Psychiatry, 127*, 240-246. doi: 10.1192/bjp.127.3.240

Roche, E., Creed, L., MacMahon, D., Brennan, D., & Clarke, M. (2014). The epidemiology and associated phenomenology of formal thought disorder: A systematic review. *Schizophrenia Bulletin*. doi: Advance online publication. doi: 10.1093/schbul/sbu129

Rochester, S. R. (1978). Are language disorders in acute schizophrenia actually information processing problems? [10.1016/0022-3956(78)90030-4]. *Journal of Psychiatric Research, 14*(1-4), 275-283.

Sans-Sansa, B., McKenna, P. J., Canales-Rodriguez, E. J., Ortiz-Gil, J., Lopez-Araquistain, L. L., Sarro, S., . . . Pomarol-Clotet, E. (2013). Association of formal thought disorder in schizophrenia with structural brain abnormalities in language-related cortical

regions. *Schizophrenia Research, 146*(1-3), 308-313. doi: 10.1016/j.schres.2013.02.032

Shenton, M. E., Kikinis, R., Jolesz, F. A., Pollak, S. D., LeMay, M., Wible, C. G., . . . Coleman, M. (1992). Abnormalities of the left temporal lobe and thought disorder in schizophrenia. A quantitative magnetic resonance imaging study. *New England Journal of Medicine, 327*(9), 604-612. doi: 10.1056/NEJM199208273270905

Sommer, R., Dewar, R., Osmond, H., & Sask, W. (1960). Is there a schizophrenic language? *Archives of General Psychiatry, 3*(6), 665-673. doi: 10.1001/archpsyc.1960.01710060097014

Stirling, J., Hellewell, J., Blakeley, A., & Deakin, W. (2006). Thought disorder in schizophrenia is associated with both executive dysfunction and circumscribed impairments in semantic function. *Psychological Medicine, 36*(4), 475-484. doi: 10.1017/S0033291705006884

Subotnik, K. L., Bartzokis, G., Green, M. F., & Nuechterlein, K. H. (2003). Neuroanatomical correlates of formal thought disorder in schizophrenia. *Cognitive Neuropsychiatry, 8*(2), 81-88. doi: 10.1080/13546800244000148

Taylor, M. A., Reed, R., & Berenbaum, S. (1994). Patterns of speech disorders in schizophrenia and mania. *Journal of Nervous and Mental Disease, 182*(6), 319-326. doi: 10.1097/00005053-199406000-00002

Vita, A. , & De Peri, L. (2013). Symptoms, thought disorders and cognitive remediation treatment in schizophrenia. In P. Brambilla & A. Marini (Eds.), *Brain evolution, language and psychopathology in schizophrenia* (pp. 212). New York: Routledge.

Weinstein, S., McKay, R., & Ngan, E. T. (2008). Positive schizotypy is not associated with speech abnormality. *Early Intervention in Psychiatry, 2*(2), 98-102. doi: 10.1111/j.1751-7893.2008.00064.x

Wilson, F. S., & Walters, R. H. (1966). Modification of speech output of near-mute schizophrenics through social-learning procedures. *Behaviour Research and Therapy, 4*(1–2), 59-67. doi: 10.1016/0005-7967(66)90043-X

Wykes, T., Huddy, V., Cellard, C., McGurk, S. R., & Czobor, P. (2011). A meta-analysis of cognitive remediation for schizophrenia: Methodology and effect sizes. *American Journal of Psychiatry, 168*(5), 472-485. doi: 10.1176/appi.ajp.2010.10060855

Appendix

Final Ethics Approval Letter (copy)

Sent: 16 November 2010
To: A/Prof Robyn Langdon
Cc: A/Prof Edwin Arthur Shores; Mr Cliff Deyo

Dear A/Prof Langdon

Re: "Schizotypy-related 'Formal Thought Disorder' and Cognitive Dysfunction" (Ethics Ref: 5201001263)

Thank you for your recent correspondence. Your response has addressed the issues raised by the Human Research Ethics Committee and you may now commence your research.

The following personnel are authorised to conduct this research: A/Prof Robyn Langdon- Chief Investigator/Supervisor; Mr Cliff Deyo & A/Prof Edwin Arthur Shores- Co-Investigators

Please note the following standard requirements of approval:

1. The approval of this project is conditional upon your continuing compliance with the National Statement on Ethical Conduct in Human Research (2007).

2. Approval will be for a period of five (5) years subject to the provision of annual reports. Your first progress report is due on 16 November 2011. If you complete the work earlier than you had planned you must submit a Final Report as soon as the work is completed. If the project has been discontinued or not commenced for any reason, you are also required to submit a Final Report for the project. Progress reports and Final Reports are available at the following website:

http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/human_research_ethics/forms

3. If the project has run for more than five (5) years you cannot renew approval for the project. You will need to complete and submit a Final Report and submit a new application for the project. (The five year limit on renewal of approvals allows the Committee to fully re-review research in an environment where legislation, guidelines and requirements are continually changing, for example, new child protection and privacy laws).

4. All amendments to the project must be reviewed and approved by the Committee before implementation. Please complete and submit a Request for Amendment Form available at the following website:

http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/human_research_ethics/forms

5. Please notify the Committee immediately in the event of any adverse effects on participants or of any unforeseen events that affect the continued ethical acceptability of the project.

6. At all times you are responsible for the ethical conduct of your research in accordance with the guidelines established by the University. This information is available at the following websites:

http://www.mq.edu.au/policy/
http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/human_research_ethics/policy

If you will be applying for or have applied for internal or external funding for the above project it is your responsibility to provide the Macquarie University's Research Grants Management Assistant with a copy of this email as soon as possible. Internal and External funding agencies will not be informed that you have final approval for your project and funds will not be released until the Research Grants Management Assistant has received a copy of this email.

If you need to provide a hard copy letter of Final Approval to an external organisation as evidence that you have Final Approval, please do not hesitate to contact the Ethics Secretariat at the address below.

Please retain a copy of this email as this is your official notification of final ethics approval.

Yours sincerely
Dr Karolyn White
Director of Research Ethics
Chair, Human Research Ethics Committee