An Examination of Neurocognitive Correlates of Social Functioning across the Psychotic Spectrum

A dissertation presented to

the faculty of

the College of Arts and Sciences of Ohio University

In partial fulfillment

of the requirements for the degree

Doctor of Philosophy

Kaley A.E. Angers

August 2022

This dissertation titled

An Examination of Neurocognitive Correlates of Social Functioning across the Psychotic Spectrum

by

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Abstract

ANGERS, KALEY, Ph.D., August 2022, Clinical Psychology

An Examination of Neurocognitive Correlates of Social Functioning across the Psychotic Spectrum

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Several studies have found that neurocognition is related to social and functional outcomes in chronic psychotic spectrum disorders and identified negative symptoms and social cognition as potential mediating mechanisms. However, few studies have examined the relationship of specific facets of neurocognition to social outcomes, though this may be of greater clinical utility. No studies to date have examined these more nuanced relationships across the psychotic spectrum, in individuals high and low in schizotypal traits, and those who recently experienced a first episode of psychosis (FEP). The present study investigated the relationship of language and social functioning across the psychotic spectrum to identify whether: 1) social and language performance differ across the spectrum, 2) language is related to social functioning across the spectrum, and 3) language is indirectly related to social functioning through negative traits/symptoms and/or social cognition.

The total sample was comprised of 101 participants: 42 low in schizotypal personality traits, 44 high in schizotypal personality traits, and 15 FEP individuals. Participants completed a comprehensive battery of language, social cognition, and social functioning tests. We found that language and social functioning performance differed by group. The FEP group performed worse than the low schizotypy group across both social

functioning and language tasks. The FEP group also performed worse on social functioning tasks than the high schizotypy group, but we observed few differences between the FEP and high schizotypy group on language measures. The high schizotypy group performed worse on social functioning than the low schizotypy group, but differences on measures of language were variable. Regression models revealed that language performance, specifically proverb interpretation, was significantly associated with performance-based social functioning. We found partial support for our exploratory mediational analyses, as language was indirectly related to social functioning through social cognition. However, negative traits were not a significant mediator. Our findings suggest that executively-mediated language tasks and social cognition may be beneficial targets of intervention for social impairment. Strengths, limitations, and future directions are discussed.

Dedication

For my mother, Jamie, whose unwavering support made this possible.

Acknowledgments

I would like to express my sincere gratitude to my doctoral advisor and dissertation chair, Dr. Julie Suhr, who has fostered my interests, encouraged my growth, and supported me through each and every clinical, academic, and research endeavor over the past six years. I would also like to Dr. Aubrey Moe who has been like a second mentor to me and provided invaluable insight into this project and my training in serious mental illness. To my remaining committee members, Dr. Timothy Anderson, Dr. Nicholas Allan, and Dr. Michelle O'Malley: thank you for your lending your expertise and providing guidance on this dissertation project. Further, I am sincerely appreciative of Cheryl Appel, Allie Binkiewicz, Taylor Williams, and Sarah Weekman, who assisted in data collection.

I would also like to acknowledge my family (my mother, Jamie; grandmother, Janice; father, Dennis; and brother, Chase) for their support, reassurance, and love. To my partner, Kirk (Smiggs), you have made this journey so much brighter, and I am eternally grateful for you. I would like to extend my utmost appreciation to my best friends whose intelligence, humor, and nurturance continually inspired and motivated me.

Finally, I would like to acknowledge the 100+ individuals who participated in this study and inspire my research. I sincerely appreciate and admire each one of you. Thank you for helping to further the scientific understanding of cognition, social functioning, and the psychotic spectrum.

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Introduction

Psychotic spectrum disorders (PSDs) are a collection of disorders characterized by diffuse psychiatric and cognitive symptoms (American Psychiatric Association, 2013). PSDs are associated with significant economic and societal consequences. For example, annual health care expenditures for schizophrenia alone are estimated at $155 billion annually in the United States (Cloutier et al., 2016). Despite the fact that many interventions exist for PSDs, treatment outcomes remain suboptimal (Breitborde et al., 2017), demonstrating the need for a more nuanced understanding of the factors contributing to functional impairments in this population.

Social impairment is a core deficit observed across all PSDs and is associated with poorer long-term outcomes, such as lower educational attainment, higher rates of unemployment, and lower likelihood of living independently (Velthorst et al., 2017). Published reviews indicate that those with PSDs report smaller social networks (Palumbo et al., 2015), diminished social support and fewer close friends (Gayer-Anderson & Morgan, 2013), greater dissatisfaction with their social support (Song et al., 2011), and poorer quality of life (Stevens et al., 2009) relative to controls. Research also demonstrates that those with PSDs evidence poorer performance on objective, performance-based measures of social functioning, compared to unaffected controls (Patterson et al., 2001; Miller et al., 2021; Sitzer et al., 2008). In addition, prior reviews and longitudinal studies find that negative symptoms (e.g., avolition, anhedonia, blunted affect) are most related to a decline in social functioning in PSDs (Correll et al., 2020; Foussias et al., 2014; Galderisi et al., 2018; Harvey et al., 2019; Milev et al., 2005);

whereas positive symptoms (e.g., hallucinations, delusions) are reportedly more amenable to pharmacologic interventions and less associated with social outcomes (Correll et al., 2020).

Prior work in PSDs suggests that social impairment may occur as a result of decrements in neurocognition. Specifically, deficits in attention, working memory, executive functioning, and language/verbal measures are often observed in those with PSDs relative to controls (Barch & Sheffield, 2014; McCleery & Nuechterlein, 2019; Sheffield et al., 2018), and such deficits are related to functional outcomes, including social impairment (Bowie et al., 2010; Green et al., 2004; Sheffield et al., 2018; Ventura et al., 2009). One published review of 18 longitudinal studies found that neurocognitive performance was predictive of psychosocial and/or functional outcomes in PSDs, with medium to large effects observed across all of the studies reviewed (Green et al., 2004). Concerning potential mediators, some findings suggest that the severity of clinical symptoms, particularly negative symptoms, mediate the relationship between neurocognition and psychosocial outcomes (Lin et al., 2013; Ventura et al., 2009). Other studies find that social cognition, or the ability to infer emotions and thoughts in others, which is also related to neurocognition and social outcomes, mediates this relationship (Addington et al., 2010; Green & Horan, 2010; Halverson et al., 2019; Schmidt et al., 2011). Given these mixed findings, future investigation into mediating mechanisms would prove beneficial.

One limitation of existing research is that many prior studies utilized a composite neurocognitive score rather than examining the differential relationships of performance

in specific neurocognitive domains to social functioning outcomes, the latter of which is likely to have more clinical utility. There is some evidence to suggest that language and verbal-based neurocognitive abilities are most strongly related to social outcomes in PSDs (Halverson et al., 2019). From a theoretical perspective, it is postulated that language deficits in PSDs arise from 1) faulty semantic memory connections (Aloia, 1998; Kuperberg, 2010; Spitzer, 1993) that result in increased spreading of activation (Spitzer et al., 1993) or semantic processing deficits (Kerns & Berenbaum, 2002); and/or 2) impairments in working memory and executive functioning (Cohen & Servan-Schreiber, 1992; Kuperberg, 2010). As such, individuals with language deficits could have difficulty expressing themselves, identifying similarities or common interests that underlie relationships, and effectively communicating with others, resulting in social impairment.

With regard to language specifically, individuals with PSDs consistently show impairments on language and related verbal-based tests compared to nonclinical controls, including performance on semantic fluency (Doughty & Done, 2009; Henry & Crawford, 2005; Kerns & Berenbaum, 2002; Szöke et al., 2008), proverb interpretation and verbal similarities (Brune & Bodenstein, 2005; Haas et al., 2015; Kiang et al., 2007; Pawelczyk et al., 2018), and verbal working memory tasks (Lee & Park, 2005; Forbes et al., 2009). Prior work demonstrates that negative symptoms specifically are related to some aspects of language performance, such as performance on tasks of fluency (Harvey et al., 2006; Brébion et al., 2013; Egeland et al., 2017) and verbal working memory (Forbes et al., 2009; González-Ortego et al., 2013; Greenwood et al., 2005). However, other studies

have not found evidence for a relationship between other aspects of language, such as proverb interpretation, and negative symptoms (Brune & Bodenstein, 2005; Haas et al., 2015; Kiang et al., 2007).

A majority of this work has been conducted in samples of individuals who have chronic and longstanding PSDs. Findings with samples of individuals with chronic PSDs are often confounded by psychiatric variables, including greater medication use, number of hospitalizations, and longer durations of (untreated) illness, all of which may affect neurocognitive and social outcomes and complicate empirical interpretation. Accordingly, many researchers have turned to the study of at risk and first episode of psychosis (FEP) samples in order to minimize many of the psychiatric confounds observed in chronic samples. Studying at risk individuals or those who recently experienced a FEP also allows researchers to better understand symptoms fundamental to PSDs and better tailor treatments in an effort to curb the economic and societal consequences associated with PSDs. Further, early intervention is considered critical, as individuals early in the course of their illness evidence better response to existing interventions (Petersen et al., 2005).

Concerning at risk samples, schizotypy refers to a constellation of personality traits that resemble positive, negative, and disorganized symptoms of PSDs, and, when combined with environmental risk factors, may result in a PSD such as schizophrenia (Barrantes-Vidal et al., 2015; Cohen et al., 2015; Debbané et al., 2015). These traits are typically present at a non-clinical threshold and are minimally interfering functionally to those who possess them as compared to those with PSDs (Cohen et al., 2015). Moreover,

schizotypy is often studied in young adult (undergraduate) samples who are of similar age to the age of onset for a FEP (Debbané et al., 2015). Prior research suggests that, in addition to sharing similar symptom factor structure, schizotypy and schizophrenia share genetic, biological, and psychosocial overlap (Barrantes-Vidal et al., 2015) and that schizotypy is predictive of later development of PSDs (Debbané et al., 2015).

Interestingly, the social and neurocognitive impairments observed in PSDs are also observed, although to a lesser extent, in FEP and schizotypy. For example, compared to unaffected control participants, individuals who recently experienced a FEP and those high in schizotypal traits report worse social functioning on self-report instruments, with medium to large effect sizes observed across studies (Aghvinian & Sergi, 2018; Aguirre et al., 2008; Cohen & Davis, 2009; Couture et al., 2007; Fonseca-Pedrero et al., 2010; Gayer-Anderson & Morgan, 2013; Gooding et al., 2014; Jaracz et al., 2007; Wang et al., 2018). Moreover, negative symptoms/traits in particular are most strongly related to self-reported social deficits (Cohen & Davis, 2009; Gooding et al., 2014; Lee et al., 2017; MacBeth et al., 2015; Puig et al., 2017), similar to chronic PSD samples. Comparatively fewer studies exist examining objective and performance-based social functioning in FEP and schizotypy, although existing studies suggest that individuals who recently experienced a FEP perform objectively worse on performance-based social functioning tasks than do unaffected controls (Cacciotti-Saija et al., 2018; Grant et al., 2001). To the author's knowledge, no studies to date have examined social functioning using a standardized performance-based assessment in individuals with schizotypy.

Language deficits emerge early in the course of psychosis (Brown & Kuperberg, 2015; Li et al., 2012; Nicolson et al., 2000), are linked to structural and functional changes in neural networks involved in psychosis (Cavelti et al., 2018; de Boer et al., 2020; Jung et al., 2019; Price et al., 2007), and reliably predict psychosis onset (Corcoran et al., 2020). Similar to individuals with PSDs, individuals who recently experienced a FEP and individuals high in schizotypal traits show poorer performance on language and verbal-based neurocognitive tests, including semantic fluency (Angers et al., 2021; Giovannetti et al., 2003; Hwang et al., 2019; Kiang & Kutas, 2006; Kravariti et al., 2009, Minor et al., 2011; Riley et al., 2000), proverb interpretation and verbal similarities (Caspi et al., 2003; Humphrey et al., 2010; Langdon et al., 2004; Maguad et al., 2014; Perlini et al., 2018; Roche et al. 2016), and verbal working memory (Bora & Murray, 2014; De Herdt et al., 2013; Ettinger et al., 2015; Siddi et al., 2017), relative to unaffected controls. The magnitude of these effects ranges from medium to large in FEP studies, whereas small to medium effect sizes are observed in schizotypy.

With regard to specific symptoms/traits, there are mixed findings as to whether language performance is related to specific symptom types in FEP and schizotypy samples. There is some evidence for a relationship between cognitive-perceptual/positive and/or disorganized symptoms and language performance (Angers et al., 2021; Kiang, 2010; Minor & Cohen, 2012; Roche et al., 2016). Fewer studies demonstrated a relationship between negative/interpersonal symptoms and language/verbal performance (Bora & Murray, 2014).

Although the most pronounced social and language deficits in individuals with PSDs are mirrored in FEP and schizotypy samples, and there is support for a relationship between language/verbal performance and social outcomes in PSDs (e.g., Halverson et al., 2019), very few studies have examined this relationship in at risk and early intervention samples. One study examined the relationship among schizotypy, atypical semantic activation (ASA) as measured by the typicality of first response to a semantic fluency task, and communication disturbances measured via the Communication Disturbance Index (Minor & Cohen, 2012). Participants were undergraduates (n = 45) who scored >95th percentile on at least one of three schizotypal factors (high schizotypy) or below the mean across all schizotypal factors (non-psychometric schizotypy; low schizotypy). The authors used categorical and dimensional approaches to assessing schizotypy and also tested whether ASA mediated the relationship between schizotypy and communication disturbances. Minor and Cohen (2012) found that the high schizotypy group evidenced more ASA than the low group, and ASA was significantly associated with positive/ cognitive-perceptual schizotypal traits. However, their mediation model was not supported. This study was limited by small sample size and was likely underpowered to detect significant effects. In addition, because prior literature suggests that cognitive deficits often precede clinical symptoms (Keefe, 2014; Sheffield et al., 2018), using schizotypy traits as a mediator and ASA as the exogenous variable may have proven more useful.

In another study, Dinzeo et al. (2018) examined whether phonemic fluency performance moderated the relationship between negative schizotypy and social

functioning in a sample of 225 undergraduate students. Those who scored 1.65 standard deviations above and below a mean schizotypal negative factor score were categorized into the high and low schizotypy groups, respectively. Dinzeo and colleagues' (2018) results indicated that poor performance on one task of phonemic fluency (letter f fluency) moderated the relationship between higher negative schizotypy and poor social functioning; in contrast, on another task of phonemic fluency (letter s fluency), better performance moderated the relationship between higher negative schizotypy and poor social functioning.

Although this study provides some support for a relationship between language performance and social functioning in schizotypy, it is not without limitations. First, the authors utilized only negative schizotypal traits to derive study groups. Second, several prior studies show that semantic fluency is more impaired than phonemic fluency across the psychotic spectrum; and although the authors measured semantic fluency, they did not report moderation analyses with semantic fluency. Perhaps most striking is that this study tested moderation, though evidence from prior reviews and large-scale studies suggest that PSD symptoms, particularly negative symptoms, mediate the relationship between neurocognitive performance and social functioning (e.g., Ventura et al., 2009; Lin et al., 2013).

To date, few studies have examined the relationship between language and social functioning in individuals with schizotypy and FEP. The studies that have examined this relationship in schizotypy have utilized only one or two tests of language, rather than a more comprehensive language battery. In addition, existing studies in schizotypy have

relied solely on self-report indices of social impairment rather than performance-based measures. Further, although schizotypy is related to the development of PSDs, few studies have examined neurocognitive and social differences across the psychotic spectrum. Finally, although studies of PSDs suggest that negative symptoms and social cognition mediate the relationship between neurocognition and social functioning in PSDs, this relationship remains unexplored in studies of schizotypy and FEP.

In the present study, we examined the relationship between language and social functioning in individuals at risk for developing psychosis (high schizotypy), individuals who recently experienced a FEP, and unaffected controls (low schizotypy). Identifying impairments in at risk and recent onset samples may help to clarify which impairments are innate in PSDs versus which are byproducts of psychiatric confounds. To address limitations in prior work, we utilized a comprehensive language battery that included tests of semantic fluency, proverb interpretation, verbal similarities, and verbal working memory; measured social functioning with both an examiner-rated subjective functioning instrument and performance-based tests; and included tests of social cognition.

The first aim was to examine group differences in language and social functioning across the psychotic spectrum. It was hypothesized that individuals with high schizotypy and FEP would exhibit poorer language and social functioning performances relative to controls with low schizotypy. The second aim was to examine whether language performance is significantly associated with social functioning. It was hypothesized that language ability would be significantly associated with, and account for a significant portion of the variance in, social functioning across the full sample. Finally, we explored

whether mediational models reported in the PSD literature were supported in our sample, testing whether 1) language is indirectly related to social functioning through interpersonal/negative schizotypal traits, or whether 2) language is indirectly related to social functioning through social cognition performance.

Method

Participants

High and Low Schizotypy Groups

The high and low schizotypy groups were recruited via two methods. First, undergraduates enrolled in introductory psychology courses completed a large prescreening assessment for course credit that included the Schizotypal Personality Questionnaire – Brief Revised Updated (SPQ; Davidson, Hoffman, & Spaulding, 2016), a well-validated measure of schizotypal traits. We screened 604 individuals using this method. Second, mass emails were sent to various colleges throughout Ohio University and its satellite campuses. The emails included links to a prescreen consent and the SPQ; 1,052 participants completed this screening process. In both methods, validity items were embedded into the SPQ (e.g., "Select 1 for this item") to control for the validity of participant responding. Those who completed all SPQ items, scored at or above the 70th percentile (high schizotypy group) and at or below the 30th percentile (control/low schizotypy group) of scores on the SPQ, passed the embedded validity check, and were 18 years or older were invited to participate.

Participants also completed the SPQ again during their study session, and those who scored below the 70th percentile and above the 30th percentile on study session SPQ were excluded from analyses (n = 15). We also excluded participants who scored <70 on a measure of crystallized verbal intelligence (n = 4) or had a history of a seizure or other neurological disorder (n = 1). Prior to beginning the study session, participants were asked to self-report whether they had been intoxicated (via alcohol or illicit substances)

within the past 24 hours; however, we did not have to exclude any participants for this reason. The final sample included 44 participants in the high schizotypy group and 42 participants in the low schizotypy control group. A history of a PSD was not reported in either group. All participant demographics are reported in Table 1.

Table 1

Demographics

	Low Schizotypy (L) *n* = 42	High Schizotypy (H) *n* = 44	First Episode of Psychosis (FEP) *n* = 15		
	M (SD)	*M (SD)*	*M (SD)*	*F*	Post-hoc comparisons, *d*
Age	21.98 (5.81)	20.41 (2.17)[c]	23.73 (3.81)[c]	3.73*	L v H = .36 L v FEP = .36 H v FEP = 1.07
Education	13.96 (1.40)	14.27 (1.51)	14.60 (2.09)	1.02	L v H = .21 L v FEP = .36 H v FEP = .18
	n (%)	*n* (%)	*n* (%)	X^2	Significant post-hoc comparisons
Gender					
Female	27 (64.29%)	31 (70.50%)	5 (33.33%)		
Male	14 (31.18)	9 (20.45%)	9 (60.00%)		
Gender non-conforming	0 (0%)	3 (6.81%)	1 (6.67%)	13.65	--
Trans-male	1 (2.38%)	0 (0%)	0 (0%)		
Trans-female	0 (0%)	0 (0%)	0 (0%)		
Agender	0 (0%)	1 (2.27%)	0 (0%)		
Race					
American Indian/ Alaskan Native	0 (0%)	0 (0%)	0 (0%)		Asian/Pacific Islander L v H, *p* = .49 L v FEP, *p* = .17 H v FEP, *p* = .063
Asian/Pacific Islander	0 (0%)	0 (0%)	2 (13.33%)	18.05*	
Black/African American	2 (4.76%)	4 (9.09%)	2 (13.33%)		
White	38 (90.48%)	34 (77.27%)	11 (73.33%)		
Bi/Multiracial	1 (2.38%)	5 (11.36%)	0 (0%)		
Other	0 (0%)	1 (2.27%)	0 (0%)		
Ethnicity Hispanic/Latino/a/x	1 (2.38%)	3 (6.81%)	0 (0%)	1.84	--

Note. [a]Low versus High comparison is significantly different; [b]Low versus FEP comparison is significantly different; [c]High versus FEP comparison is significantly different. ***p<.001, **p<.01, *p<.05.

Exploratory FEP Group

A sample of patients who recently experienced a FEP were recruited from the Early Psychosis Intervention Center (EPICENTER) Clinic at The Ohio State University. All individuals enrolled in the Clinic were required to meet the following clinic entry

criteria: 1) FEP experienced within the past five years diagnosed by an affiliated psychologist and/or psychiatrist, excluding substance-induced psychosis, 2) estimated premorbid intelligence of ≥70. Individuals who previously provided consent to be contacted for ongoing research studies at EPICENTER were invited to participate in the current study. In addition, all Clinic staff were provided with information about the study and asked to inform their patients of the research study.

Those who expressed interest were given contact information for study staff. In total, 21 patients expressed interest in the study; one was determined ineligible due to age, three were unable to be reached for scheduling, and two cancelled. The final FEP sample consisted of 15 patients. The average age at onset for FEP was 21.93 (3.63) years. On average, participants experienced their FEP two years prior to study participation (range: 0-4 years). Most patients (93%) were prescribed an atypical (i.e., second generation) antipsychotic medication at the time of participation. A majority of patients (93%) had been previously hospitalized for PSD symptoms. Demographics are reported in Table 1.

Measures

As part of the larger study, participants completed a large neurocognitive test battery. For the purposes of the current study, only the measures of interest will be discussed. A copy of each noncopyrighted measure used in the present study can be found in Appendix A.

Demographics, Psychological History, and Current Psychological Symptoms

We collected information pertaining to participant demographics and schizotypal symptoms via REDCap, a HIPAA-compliant electronic data capture system. The schizotypy groups also completed a psychological history questionnaire within REDCap. For the FEP group only, we obtained psychological history via medical record review. FEP participants also completed a semi-structured interview of their current psychosis symptoms: the Positive and Negative Syndrome Scale for Schizophrenia (PANSS; Kay et al., 1989).

SPQ. The SPQ (Davidson et al., 2016**)** is a 32-item self-report measure used to assess schizotypal traits. Responses are made on a 5-point ordinal scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The scale contains nine subscales: Suspiciousness, Ideas of Reference, Magical Thinking, Unusual Perceptions, No Close Friends, Constricted Affect, Social Anxiety, Odd Speech, and Eccentric Behavior. The SPQ is well-validated and shows excellent internal consistency in young adult samples (Davidson et al., 2016). For the present analyses, scores from the SPQ completed at the study session were used. We calculated total and higher-order factor scores (i.e., positive/cognitive-perceptual [14 items], negative/interpersonal [10 items], disorganized [8 items]), consistent with prior work (Davidson et al., 2016). Internal consistency was excellent in our sample, total SPQ, $\alpha = .96$; interpersonal factor, $\alpha = .92$; cognitive-perceptual factor, $\alpha = .91$; and disorganized factor, $\alpha = .92$. SPQ endorsement by group is reported in Table 2.

Table 2

Current Psychological Symptoms and Psychological History

	Low Schizotypy (L) *n* = 42	High Schizotypy (H) *n* = 44	First Episode of Psychosis (FEP) *n* = 15		
	M (SD)	*M (SD)*	*M (SD)*	*F*	Post-hoc comparisons, *d*
Total SPQ	65.40 (9.67)[ab]	117.48 (9.55)[ac]	96.20 (15.63)[bc]	256.26***	L v H = 5.42 L v FEP = 2.37 H v FEP = 1.64
SPQ Interpersonal Factor	20.50 (5.70)[ab]	37.75 (5.57)[ac]	29.67 (7.64)[bc]	89.95***	L v H = 3.06 L v FEP = 1.36 H v FEP = 1.20
SPQ Cognitive-Perceptual Factor	24.33 (6.08)[ab]	46.22 (7.50)[ac]	38.60 (7.70)[bc]	107.07***	L v H = 3.21 L v FEP = 2.06 H v FEP = 1.00
SPQ Disorganized Factor	20.57 (5.59)[ab]	46.23 (7.50)[ac]	27.93 (6.51)[bc]	69.42***	L v H = 3.88 L v FEP = 1.21 H v FEP = 2.61
PANSS Total	--	--	48.20 (7.20)	--	--
PANSS Positive Subscale	--	--	10.53 (3.36)	--	--
PANSS Negative Subscale	--	--	11.53 (4.74)	--	--
PANSS General Psychopathology Subscale	--	--	26.13 (4.82)	--	--

Table 2 continued: *Current Psychological Symptoms and Psychological History*

	n (%)	*n* (%)	*n* (%)	X^2	Significant post-hoc comparisons
Psychological History					Depression
					L v H, $p = .008$
Depression	10 (23.80%)[a]	23 (52.27%)[c]	2 (13.33%)[ac]	11.22**	L v FEP, $p = .33$
Bipolar Disorder	1 (2.38%)	2 (4.76%)	1 (6.67%)	.60	H v FEP, $p = .008$
Anxiety	8 (19.05%)[a]	25 (56.82%)[a]	6 (40.00%)	12.95**	Anxiety
Substance Use Disorder	1 (2.38%)	2 (4.54%)	0 (0%)	.89	L v H, $p<.001$
					L v FEP, $p = .10$
PTSD	1 (2.38%)[a]	9 (20.45%)[ac]	0 (0%)[c]	9.80**	H v FEP, $p = .20$
ADHD	4 (9.52%)[ab]	10 (22.73%)[a]	7 (46.67%)[b]	9.44**	PTSD
Learning Disorder	3 (7.14%)	5 (11.36%)	3 (20.00%)	1.90	L v H, $p = .009$
					L v FEP, $p = .74$
Schizophrenia	0 (0%)[b]	0 (0%)[c]	5 (33.33%)[bc]	30.16***	H v FEP, $p = .05$
Schizoaffective	0 (0%)[b]	0 (0%)[c]	4 (26.67%)[bc]	23.88***	ADHD
Psychosis NOS	0 (0%)[b]	0 (0%)[c]	3 (20.00%)[bc]	17.73***	L v H, $p = .09$
Affective Disorder with Psychotic Features	0 (0%)[b]	0 (0%)[c]	3 (20.00%)[bc]	17.73***	L v FEP, $p = .004$
					H v FEP, $p = .07$
Psych Hospitalization	1 (2.38%)	5 (11.36%)	14 (93.33%)	61.07***	L v H, $p = .11$
					L v FEP, $p<.001$
					H v FEP, $p<.001$

Note. [a]Low versus High comparison is significantly different; [b]Low versus FEP comparison is significantly different; [c]High versus FEP comparison is significantly different. ***$p<.001$, **$p<.01$, *$p<.05$.

PANSS. For the FEP group only, we assessed current psychological symptoms via the PANSS (Kay et al., 1989). This is a 30-item semi-structured interview that contains subscales for Positive (7 items), Negative (7 items), and General Psychopathology (16 items) symptoms. Each symptom item is rated on a 1 (not present) to 7 (extreme) scale. Total and subscale scores were calculated. In the present study, the rater completed training and met EPICENTER inter-rater reliability criteria (ICC [absolute agreement] > 0.75) as compared to master ratings. On average, our FEP sample did not appear in acute psychiatric distress (see Table 2).

Language

Semantic Fluency Tests. Semantic fluency tasks require participants to generate as many words as they can to fit a specific category in one minute. In adults, semantic fluency tests show acceptable test-retest reliability and convergent validity, as well as adequate discriminant validity in schizophrenia samples (Melinder et al. 2005). We utilized the Animals, Fruits, and Vegetables categories, as they are most represented in PSD literature. We analyzed this data in two ways. First, we calculated the number of responses generated based on standard scoring criteria (i.e., no repeats, no proper nouns) and created an average total score across the three categories, then calculated a z-score based on the full sample. Second, we employed content-based analyses to derive a semantic infrequency score from each category, consistent with our prior published work (Angers et al., 2021).

To do so, we created a semantic corpus for each category based on all participant responses for the category. For each corpus, the responses are rank-ordered based on how often they were generated in the full sample, with higher values assigned to more infrequent responses. For example, if in the fruit category "apple" is the most frequently generated word, a value of 1 is assigned, and if "kumquat" is the 42nd most frequently generated word, a value of 42 is assigned. Each participant's responses are coded in this manner. Then, we summed each participant's responses and divided by the total number of words produced, to generate a mean semantic infrequency for each category. Last, we averaged semantic infrequency scores across the three categories to create an overall

semantic infrequency score. We used this variable as a dependent variable in Aim 1 and independent variable in Aims 2 and 3.

Similarities. Similarities is a Wechsler Adult Intelligence Scale-IV (WAIS-IV; Wechsler, 2008) subtest that measures verbal abstract reasoning. Participants are asked to describe how two objects are alike (e.g., "In what way are two and seven alike?"), and the items become more abstract as the test advances. Prior research demonstrates high internal consistency and test-retest reliability in young adult samples, and adequate convergent validity with other verbal tasks (Wechsler, 2008). In the present study, we used the total scaled score, which adjusts for participant age, as a dependent variable in Aim 1 and independent variable in Aims 2 and 3.

Proverb Test. The Delis-Kaplan Executive Function System - Proverb Test measures verbal abstraction and requires participants to interpret proverbs (e.g., "Don't count your chickens before they are hatched."). Each response is rated on accuracy (i.e., inclusion of key elements) and abstraction (i.e., ability to generalize). This test demonstrates adequate internal consistency and test-retest reliability in adult samples (Delis, et al., 2001) and convergent validity with other abstract reasoning tasks (Kiang et al., 2007). We utilized the Achievement scaled score, which accounts for the accuracy and abstraction of participant responses and adjusts for age, as a dependent variable in Aim 1 and independent variable in Aims 2 and 3.

Digit Span. Digit Span is a WAIS-IV subtest that measures verbal working memory (Wechsler, 2008). This task requires participants to listen to strings of single-digit numbers and repeat them in forward, backward, and sequencing orders.

Performance is summed to create a total score. Digit Span shows high internal consistency and acceptable test-retest reliability in young adult samples (Weschler, 2008). We used the total scaled score, which adjusts for age, as a dependent variable in Aim 1 and independent variable in Aims 2 and 3.

Social Cognition

Hinting Task. This is a theory of mind task that requires participants to infer meaning during indirect conversations (Corcoran et al., 1995). Participants are presented with ten social interaction vignettes read aloud by the examiner. In each vignette, one of the characters makes a hint to the other character, and the participant is asked to infer the meaning. If the participant's response is inaccurate, another hint is administered. Scores range from 0-20, with higher scores reflecting better performance. The Hinting Task shows adequate internal consistency, test-retest reliability, and convergent validity (Pinkham et al., 2018). We used the total score on this measure to derive a social cognition variable that was used as a mediator variable in Aim 3. See the Statistical Analyses section for details.

Affect Naming. This subtest is a measure of affect recognition included in the Social Perception portion of the Advanced Clinical Solutions tests associated with the WAIS-IV (Pearson, 2009). Affect Naming requires participants to identify the emotion displayed in photographs of human faces (i.e., happy, sad, angry, afraid, surprised, disgusted, or neutral). In schizophrenia, internal consistency is high and test-retest reliability is acceptable (Pearson, 2009). We used the Affect Naming scaled score, which

adjusts for age, to derive a social cognition variable that was utilized as a mediator variable in Aim 3. See the Statistical Analyses section for details.

Social Functioning

Global Functioning: Social (Gf: Social). This is a semi-structured interview examining the quality and quantity of social relationships and interactions over the past month (Cornblatt et al., 2007). The examiner rates the participant's social functioning on a 1 (extreme social isolation) to 10 (superior social/interpersonal functioning) scale based on the participants self-report of their social functioning. Due to the COVID-19 pandemic, we completed the measure a second time to assess for COVID-related social changes. In the present study, a rater completed training with a master coder and met inter-rater reliability criteria (ICC [absolute agreement] > 0.75) as compared to master ratings; following training, all study data was rated by that trained rater. GF: Social performance is utilized as a measure of subjective social functioning Aims 1, 2, and 3.

Social Skills Performance Assessment (SSPA). The SSPA is a performance-based social functioning assessment requiring participation in three video-recorded role plays (Patterson et al., 2001). In each role play, the participant is administered a written prompt describing the scenario. The first role play is designed to acclimate the participant to the task and is not scored. The second role play assesses initiation and maintenance of conversation, and participants are rated on their interest, fluency, clarity, focus, affect, grooming, overall conversation, and social appropriateness. The third role play assesses social problem-solving skills, and participants are rated on their interest, fluency, clarity, focus, affect, negotiation ability, submission/persistence, overall argument, and social

appropriateness. All ratings are made on a 5-point, 1 “Low” to 5 “High” scale. We created an average score for role play 2 and another for role play 3. Internal consistency estimates in the present study were good (role play 2 $\alpha = .80$, and role play 3 $\alpha = .85$). Inter-rater reliability between the study rater and master rater ranged from $\alpha = .76\text{-}1.00$ for role play 2 and $\alpha = .90\text{-}1.00$ for role play 3. This met inter-rater reliability criteria established in the EPICENTER Clinic (i.e., ICC [absolute agreement] > 0.75). We utilized SSPA scores as dependent variables in all study aims. See the Statistical Analyses section for details.

Potential Covariates

Vocabulary. Vocabulary is a WAIS-IV subtest that measures word knowledge, an aspect of crystallized intelligence (Wechsler, 2008). Participants are asked to define words to the best of their ability. Internal consistency and test-retest reliability are excellent in young adult samples, and Vocabulary shows high convergent validity with other verbal tests (Wechsler, 2008). Vocabulary scaled score was examined as a potential covariate.

Stroop Color and Word Test. The Word Reading trial of The Stroop Color and Word Test (Golden, 1978) measures verbal processing speed. In this trial, the participant is presented with a sheet containing 100 color words (i.e., red, blue, green) and instructed to read aloud as many words as they can in 45 seconds. T-score adjusting for participant age was examined as a potential covariate in analyses, given the speed of verbal processing could influence language performances, particularly on timed tests.

COVID-19 Impact Battery – Short (CIBS). The CIBS (Schmidt et al., 2021) is a five-item measure that assesses COVID-related stress over the past 30 days (e.g., "I worry I will be unable to provide for my family during this time of COVID-19"). Responses are made on a five-point scale from 0 (Not at all) to 4 (Very much). Prior work demonstrates acceptable reliability and validity estimates in adult samples (Schmidt et al., 2021). In the present study, the internal consistency was also acceptable, $\alpha = .70$. The total score was examined as a potential covariate in analyses, as data were collected during the COVID-19 pandemic.

Procedure

All study sessions took place via a secure video platform, Microsoft Teams. All participants met eligibility criteria and confirmed accessibility requirements (i.e., a device with at least an 8-inch screen and stable Internet) prior to their study session. Either a master's level clinician or trained research assistant administered the study protocol in the schizotypy groups; only a master's level clinician worked with FEP participants. At the beginning of each study session, a contingency plan was discussed regarding reconnecting to the study session if there was a disruption. As described above, we asked participants about substance intoxication within 24 hours of their scheduled appointment time.

All participants were sent a REDCap link to the informed consent. After its completion, participants were sent another REDCap link to complete demographics, psychological history (for schizotypy groups only), and the SPQ. Only the FEP group completed the PANSS. Participants completed study tasks in a standard sequenced order.

At study completion, participants were debriefed, provided with a resource sheet, and awarded either 2 study credits or a $25 Amazon gift card if they were in either schizotypy condition. Those in the FEP condition were provided with a $50 Amazon gift card, as they completed an additional interview and provided access to their medical records.

Statistical Analyses

SPSS v27 was utilized for all analyses. First, we explored demographic differences across the three study groups to determine demographic covariates. In addition, we provided descriptive statistics for current psychological symptoms and psychological history.

In Aim 1, we examined group differences in (1) language ability and (2) social functioning across the psychotic spectrum via two MANCOVAs. All data were examined for normality; only the averaged semantic infrequency data violated this assumption and was positively skewed. Two outlier cases were Winsorized to fall within 3 SDs of the sample mean, consistent with our prior work (Angers et al., 2021). After Winsorizing, all data was approximately normally distributed. Concerning covariates, we observed group differences in Stroop Word Reading T-score and CIBS total score. Through correlational analyses, we determined that Stroop Word Reading was significantly linearly related to all language and social variables, deeming it an appropriate covariate in both models (i.e., language and social MANCOVAs). Because COVID-19 may have negatively impacted social functioning, and we observed a significant association between GF: Social ratings and CIBS total score, we also entered total CIBS score as a covariate in the social functioning MANCOVA only.

The GF: Social traditional and COVID-19 ratings were highly correlated (r >.70), violating the multicollinearity assumption for the social functioning MANCOVA. Accordingly, the two ratings were aggregated in the social functioning MANCOVA model. We did not find any further evidence for violation of test assumptions, including homogeneity of variance and covariance assumptions. Significant MANCOVAs were followed with one-way ANCOVAs to determine which performances significantly differed and to conduct a priori group comparisons consistent with our hypotheses.

In Aim 2, we examined the relationship of language performance to social functioning via zero-order correlations and hierarchical linear regression. Our study variables were normally distributed and linearly related. We did not find evidence of multicollinearity or heteroscedasticity. We proceeded with four hierarchical regression models, one for each of the social functioning dependent variables. At step one, we entered covariates: Stroop Word Reading T-score and CIBS score. At step two, we entered each language variable (semantic fluency z-score, averaged semantic infrequency, Proverb Test Achievement scaled score, Similarities scaled score, and Digit Span scaled score). For each model, we examined whether specific language skills accounted for unique variance in social functioning.

As an exploratory aim, we investigated mediational models reported in the chronic PSD literature using the Version 4.0 of the PROCESS macro Model 4 (Hayes, 2022). For these analyses, we created averaged z-scores for language, social cognition, and social functioning. The language z-score was created by averaging the z-scores calculated for semantic fluency, semantic infrequency, Similarities scaled score, Proverb

Test Achievement scaled score, and Digit Span scaled score. The social functioning z-score was created by averaging z-scores calculated for the two GF: Social ratings, and the two scored SSPA role plays. We also calculated a social cognition z-score by averaging z-scores calculated for the Hinting Task total score and Affect Naming scaled score. In each model, language was the independent variable and social functioning was the dependent variable. We entered interpersonal/negative traits as the mediator in the first model, and social cognition as the mediator in the second model.

Results

Full Sample Demographics

Demographics by group membership (i.e., low schizotypy controls, high schizotypy, FEP) are reported in Table 1. The groups differed in age, $F(2, 98) = 3.73$, $p = .03$, with the FEP group being significantly older than the high schizotypy group, as expected; however, there was no further evidence of group differences in age, all *ps* >.05. The groups also differed in race, $X^2(8, N = 99) = 18.05$, $p = .03$; specifically, the groups differed in the percent of individuals identifying as Asian/Pacific Islander, $X^2(2, N = 101) = 6.99$, $p = .03$, with the FEP group being comprised of marginally more Asian/Pacific Islander individuals than the high schizotypy group, $X^2(2, N = 59) = 6.07$, $p = .06$. No other group differences were observed in race, all *p*s >.05. The groups did not differ in education, $F(2, 97) = 1.02$, $p = .37$, gender, $X^2(8, N = 101) = 13.65$, $p = .09$, or ethnicity, $X^2(2, N = 101) = 1.84$, $p = .40$.

Concerning schizotypal traits, the groups differed in their endorsement of total schizotypal traits, $F(2, 98) = 256.26$, $p <.001$, interpersonal traits, $F(2, 98) = 89.95$, $p <.001$, cognitive-perceptual traits, $F(2, 98) = 107.07$, $p <.001$, and disorganized traits, $F(2, 98) = 69.42$, $p <.001$. More specifically, the high schizotypy group endorsed significantly higher total, interpersonal, cognitive-perceptual, and disorganized schizotypal traits than the FEP and low schizotypy control groups, all *ps* <.05, *ds* = 1.00-5.42. The FEP group endorsed significantly higher total, interpersonal, cognitive-perceptual, and disorganized schizotypal traits than the low schizotypy controls, all *ps* <.05, *ds* = 1.20-2.37. When examining differences in psychological history among the

groups, the groups differed in depression, $X^2(2, N = 101) = 11.22$, $p = .004$, anxiety, $X^2(2, N = 101) = 12.95$, $p = .002$, post-traumatic stress disorder (PTSD), $X^2(2, N = 101) = 9.80$, $p = .007$, and attention-deficit/ hyperactivity disorder (ADHD) histories, $X^2(2, N = 101) = 9.44$, $p = .009$, but not in their histories of other disorders, *all ps* >.05. More specifically, the high schizotypy group was comprised of a greater proportion of individuals who reported a history of depression without psychotic features than the FEP group, $X^2(2, N = 59) = 6.95$, $p = .01$; the high schizotypy group was comprised of a greater proportion of individuals who reported a history of anxiety, $X^2(2, N = 86) = 12.96$, $p<.001$, and PTSD, $X^2(2, N = 86) = 6.83$, $p = .02$, than the low schizotypy control group; and the FEP group was comprised of a greater proportion of individuals who a reported history of ADHD than the low schizotypy group, $X^2(2, N = 57) = 9.79$, $p = .004$. As expected based on recruitment strategy, no participants in the schizotypy groups reported a history of a PSD, while in the FEP group, all participants carried a PSD diagnosis. See Table 2.

Table 3 depicts group differences across all study variables, including potential covariates. The three groups did not significantly differ in their Vocabulary scaled score, $F(2, 98) = 1.97$, $p = .14$; therefore, Vocabulary was not utilized as a covariate in subsequent analyses. In contrast, the groups differed in Stroop Word Reading performance, $F(2, 98) = 4.85$, $p = .01$, with both the FEP group ($p = .02$, $d = .77$) and the high schizotypy group ($p = .04$, $d = .54$) exhibiting slower performance speed than the low schizotypy group. In bivariate correlations, Stroop Word Reading was significantly associated with all language and social functioning variables, all *rs* = .21-.39, all *ps* <.05,

with the exception of averaged infrequency, $r(101) = .18$, $p = .07$. Accordingly, we used Stroop Word Reading as a covariate in analyses for Aims 1 and 2.

The groups also differed in their report of COVID-19 stress via the CIBS, $F(2, 98) = 19.74$, $p < .001$, with the high schizotypy group endorsing more stress than the low schizotypy group, $p < .001$, $d = 1.43$. The high schizotypy and FEP, and low schizotypy and FEP comparisons were not statistically significant, all *ps* >.05, *ds* = .58-.64. When examining bivariate correlations, CIBS total score was significantly associated with aggregate GF: Social performance, $r(101) = -.37$, $p < .001$, but not with SSPA role plays or any language measures, all *rs* -.18 -.06, all *ps* >05. Therefore, we utilized total CIBS total score as a covariate in social functioning MANCOVA analyses in Aim 1 and in all analyses in Aim 2.

Table 3

Language, Social Functioning, and Social Cognition Performance across Groups

	Low Schizotypy (L) *n* = 42	High Schizotypy (H) *n* = 44	First Episode of Psychosis (FEP) *n* = 15		
	M (SD)	*M (SD)*	*M (SD)*	*F*	Post-hoc comparisons, *d*
Language					
Semantic Infrequency	26.00 (8.55)	26.12 (6.89)	28.04 (9.16)	.40	L v H = .02 L v FEP = .23 H v FEP = .24
Semantic Fluency z-Score	.30 (.83)[b]	-.05 (.94)	-.68 (1.28)[b]	5.84**	L v H = .39 L v FEP = .91 H v FEP = .56
Similarities Scaled Score	12.04 (2.13)	11.68 (2.18)	11.87 (2.56)	1.18	L v H = .17 L v FEP = .07 H v FEP = .08
Achievement Scaled Score	11.71 (2.12)[ab]	10.11 (2.93)[a]	8.93 (3.37)[b]	7.17**	L v H = .63 L v FEP = .99 H v FEP = .37
Digit Span Scaled Score	10.43 (3.12)[b]	10.19 (2.39)	8.33 (2.29)[b]	3.46*	L v H = .09 L v FEP = .77 H v FEP = .79
Language z-score	.16 (.62)	-.08 (.54)	-.27 (.87)	3.03*	L v H = .41 L v FEP = .57 H v FEP = .26
Social Functioning					
GF: Social Traditional	8.48 (.59)[ab]	7.07 (.93)[ac]	6.20 (.68)[bc]	64.46***	L v H = 1.81 L v FEP = 3.58 H v FEP = 1.07
GF: Social COVID-19	8.19 (.77)[ab]	6.98 (.89)[ac]	6.13 (.74) [bc]	43.04***	L v H = 1.45 L v FEP = 2.73 H v FEP = 1.04
SSPA Role Play 2	4.95 (.10)[ab]	4.67 (.36 [ac]	4.44 (.47) [bc]	43.04***	L v H = 1.06 L v FEP = 1.50 H v FEP = .55
SSPA Role Play 3	4.85 (.22)[ab]	4.41 (.39)[ac]	4.22 (.62) [bc]	21.24***	L v H = 1.39 L v FEP = 1.35 H v FEP = .37
Social functioning z-score	.69 (.37) [ab]	-.31 (.63) [ac]	-.98 (.88) [bc]	57.42***	L v H = 1.94 L v FEP = 2.47 H v FEP = .88
Social Cognition					

Table 3 continued: *Language, Social Functioning, and Social Cognition Performance across Groups*

Hinting Task Total Score	16.48 (1.55)[b]	15.79 (1.62)[c]	13.67 (2.97)[bc]	12.74***	L v H = .44 L v FEP = 1.18 H v FEP = .87
Affect Naming Scaled Score	9.71 (2.94)	9.05 (2.80)	7.93 (2.37)	2.29	L v H = .23 L v FEP = .67 H v FEP = .43
Social Cognition z-score	.28 (.72)[b]	-.03 (.73)[c]	-.72 (.98)[bc]	9.35***	L v H = .43 L v FEP = 1.16 H v FEP = .80
Potential Covariates					
Stroop Word Reading T-score	44.10 (8.23)[ab]	39.91 (7.34)[a]	37.73 (8.31)[b]	4.85**	L v H = .54 L v FEP = .77 H v FEP = .27
CIBS Total Score	4.52 (3.42)[a]	9.55 (3.61)[a]	7.13 (4.67)	19.74***	L v H = 1.43 L v FEP = .64 H v FEP = .58
Vocabulary Scaled Score	13.40 (2.60)	12.82 (2.34)	11.80 (3.93)	1.97	L v H = .23 L v FEP = .48 H v FEP = .32

Note. [a]Low versus High comparison is significantly different; [b]Low versus FEP comparison is significantly different; [c]High versus FEP comparison is significantly different. ***p<.001, **p<.01, *p<.05.

Group Differences in Language Ability and Social Functioning

Language Ability

Results provided some support for our hypothesis that the FEP and high schizotypy groups would show poorer language performance than the low schizotypy control participants. A one-way MANCOVA revealed a statistically significant difference in language performance among the participant groups after controlling for Stroop Word Reading performance, $F(10, 182) = 2.10$, $p = .026$, *Wilks' Λ* = .80, $\eta_p^2 = .10$. Follow-up ANCOVAs showed that the groups differed in performance on both semantic fluency and the Proverb Test, after controlling for Stroop Word Reading, $F(2, 96) = 2.67$, $p = .044$, $\eta_p^2 = .063$, and $F(2, 97) = 4.74$, $p = .011$, $\eta_p^2 = .089$, respectively. Post hoc tests showed

that the FEP group generated significantly fewer responses on semantic fluency than the low schizotypy controls (p = .049, d = .75). There was no statistically significant difference between the high schizotypy and low schizotypy groups (p = .99, d = .17), or the FEP and high schizotypy groups (p = .14, d = .60).

Additional post hoc tests showed that the FEP group performed significantly worse than the low schizotypy controls on the Proverb Test (p = .016, d = .87). There was no statistically significant difference between the high schizotypy and low schizotypy groups (p = .083), though the magnitude of the differences between the two groups was medium (d = .52), and there was no significant difference in performance between the FEP group and high schizotypy group (p = .59, d = .36). The three groups did not differ in their performance on semantic infrequency, $F(2, 97) = .96$, p = .39, η_p^2 = .019, Similarities, $F(2, 97) = .38$, p = .68, η_p^2 = .008, or Digit Span, $F(2, 97) = 2.21$, p = .12, η_p^2 = .044. See Table 4.

Table 4

Language Variables by Group, Controlling for Verbal Processing Speed

	Low Schizotypy n = 42	High Schizotypy n = 44	First Episode of Psychosis n = 15	
	EMM (SE)	*EMM (SE)*	*EMM (SE)*	η_p^2
Semantic Infrequency	25.55 (1.27)	26.39 (1.22)	28.78 (2.07)	.018
Semantic Fluency z-score	.18(.15)[b]	.014 (.14)	-.54 (.24)[b]	.063
Similarities Scaled Score	12.16 (.35)	11.83 (.33)	12.17 (.57)	.006
Proverb Test Scaled Score	11.57 (.43)[b]	10.15 (.41)	9.16 (.70)[b]	.094
Digit Span Scaled Score	10.12 (.41)	10.38 (.39)	8.78 (.67)	.044

Note. [a]Low versus High comparison is significantly different; [b]Low versus FEP comparison is significantly different; [c]High versus FEP comparison is significantly different. All significant comparisons are adjusted for multiple comparisons using the Bonferroni method

Social Functioning

Results supported our hypothesis that both the FEP and high schizotypy groups would show poorer social functioning relative to the low schizotypy control participants. A one-way MANCOVA revealed there was a statistically significant difference among the groups on social functioning performance, after controlling for Stroop Word Reading and CIBS score, $F(6, 190) = 10.61$, $p < .001$, *Pillai's Trace* = .50, $\eta_p^2 = .25$. Follow-up ANCOVAs showed group differences on the GF: Social, after controlling for Stroop Word Reading and CIBS score, $F(2, 96) = 37.55$, $p < .001$, $\eta_p^2 = .44$. Post hoc tests showed that the FEP group was rated as significantly more impaired on the GF: Social than the high schizotypy ($p < .001$, $d = 1.09$) and low schizotypy groups ($p < .001$, $d = 2.41$). The high schizotypy group was rated as more impaired on the GF: Social than the low schizotypy control group ($p < .001$, $d = 1.38$).

With regard to performance-based social functioning, ANCOVAs revealed there was a significant main effect of SSPA role play 2 performance by participant group, after controlling for Stroop Word Reading and CIBS score, $F(2, 96) = 15.99$, $p < .001$, $\eta_p^2 = .25$. Post hoc tests showed both the FEP and high schizotypy groups performed significantly worse on role play 2 than the low schizotypy group, $p < .001$, $d = 1.62$, and $p < .001$, $d = .95$, respectively. However, the FEP and high schizotypy group did not differ in their performance, $p = .084$, $d = .64$.

We observed a similar pattern of findings in SSPA role play 3; there was a significant main effect of the SSPA role play 3 performance by participant group, after controlling for Stroop Word Reading and CIBS score, $F(2, 96) = 15.84$, $p < .001$, $\eta_p^2 = .25$.

Post hoc tests showed the FEP and high schizotypy groups performed significantly worse than the low schizotypy group, $p<.001$, $d = 1.40$, and $p<.001$, $d = 1.05$, respectively. However, the FEP and high schizotypy group did not differ, $p = .59$, $d = .39$. See Table 5.

Table 5

Social Functioning Variables by Group, Controlling for Verbal Processing Speed and COVID-19 Stress

	Low Schizotypy $n = 42$	High Schizotypy $n = 44$	First Episode of Psychosis $n = 15$	
	EMM (SE)	*EMM (SE)*	*EMM (SE)*	η_p^2
GF: Social Aggregate	8.22 (.13)[ab]	7.09 (.12)[ac]	6.23 (.20)[bc]	.44
SSPA Role Play 2	4.97 (.05)[ab]	4.66 (.05)[a]	4.45 (.08)[b]	.25
SSPA Role Play 3	4.85 (.07)[ab]	4.40 (.06)[a]	4.25 (.09)[b]	.25

Note. [a]Low versus High comparison is significantly different; [b]Low versus FEP comparison is significantly different; [c]High versus FEP comparison is significantly different. All significant comparisons are adjusted for multiple comparisons using the Bonferroni method.

The Relationship between Language Ability and Social Functioning

All findings are reported in Tables 6 and 7. See Table 6 for zero-order correlations among study variables. See Table 7 for a summary of the hierarchical multiple regression models.

Table 6

Correlations among Covariates, Language Variables, and Social Functioning Variables

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. Stroop Word Reading T-score	--										
2. CIBS Total Score	-.16	--									
3. Semantic Infrequency	.18	.06	--								
4. Semantic Fluency z-score	.38***	-.05	.11	--							
5. Similarities SS	.31**	-.10	.30**	.29**	--						
6. Proverb Test Achievement SS	.28**	-.11	.18	.33***	.34***	--					
7. Digit Span SS	.39***	-.04	.12	.31**	.23*	.20*	--				
8. GF: Social Traditional	.37***	-.36***	-.05	.31**	.15	.24*	.19	--			
9. GF: Social COVID-19	.31**	-.37***	-.13	.21*	.08	.24*	.14	.91***	--		
10. SSPA Role Play 2	.21*	-.11	.02	.16	.17	.34***	.24*	.59***	.56***	--	
11. SSPA Role Play 3	.29**	-.18	.06	.18	.23*	.37***	.22*	.53***	.48***	.70***	--

Note. SS = Scaled Score. ***p<.001, **p<.01, *p<.05.

Table 7

Hierarchical Multiple Regression with Language Predicting Social Functioning

	GF: Social Traditional			GF: Social COVID-19			SSPA Role Play 2			SSPA Role Play 3		
	B	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Step 1												
Stroop Word Reading T-score	.05***	.01	.33	.04**	.01	.26	.009*	.004	.22	.02**	.005	.28
CIBS Total Score	-.08***	.02	-.32	-.08***	.02	-.32	-.006	.008	-.07	-.01	.01	-.12
Step 2												
Semantic Infrequency	-.02	.01	-.11	-.02	.12	.08	-.002	.004	-.06	-.002	.006	-.03
Semantic Fluency z-score	.21	.11	.18	.085	.12	.08	-.008	.038	-.024	-.014	.05	-.03
Similarities SS	-.014	.05	-.03	-.03	.05	-.06	.001	.02	.007	.01	.02	.06
Proverb Test Achievement SS	.044	.04	.11	.07	.04	.17	.04**	.01	.31	.05**	.02	.30
Digit Span SS	.01	.04	.03	.01	.04	.02	.02	.01	.15	.02	.02	.11

Note. SS = Scaled Score. ***p<.001, **p<.01, *p<.05.

Language and Subjective Social Functioning

The first two models did not support our hypothesis that language was significantly linearly related to social functioning as measured via the GF: Social. Zero-order correlations showed that a better GF: Social traditional rating was significantly associated with better performance on semantic fluency, $r(99) = .31$, $p = .001$, and the Proverb Test, $r(101) = .23$, $p = .02$. We did not observe any further significant correlations between the GF: Social traditional rating and the remaining language variables, all *rs* = -.05-.19, all *ps* $\geq$.05. In step one of the regression model for the GF: Social traditional rating, Stroop Word Reading and CIBS score jointly accounted for a significant portion of variance, $F(2, 96) = 15.33$, $p<.001$, $\Delta R^2 = .24$. The second block, comprised of the five language variables, did not significantly account for additional variance in the GF: Social traditional rating, $F(5, 91) = 1.47$, $p = .21$, $\Delta R^2 = .057$.

Similar results were seen for the GF: Social COVID-19 rating. Zero-order correlations showed that a better GF: Social COVID-19 rating was significantly associated with better performance on semantic fluency, $r(99) = .21$, $p = .04$, and the Proverb Test, $r(101) = .24$, $p = .01$. The GF: Social COVID-19 rating was not significantly correlated with any other language variable, all *rs* = -.13-.14, all *ps* >.05. In the first step of the regression model for the GF: Social COVID-19 rating, Stroop Word Reading and CIBS score jointly accounted for a significant amount of variance in the GF: Social COVID-19 rating, $F(2, 96) = 12.12$, $p<.001$, $\Delta R^2 = .20$. In the second step, language performance did not significantly account for additional variance in the GF: Social COVID-19 rating, $F(5, 91) = 1.41$, $p = .23$, $\Delta R^2 = .057$.

Language and Objective Social Functioning

The third and fourth models did support our hypotheses that language was significantly related to social functioning, as measured by performance-based assessments of social functioning. Better performance on SSPA role play 2 was significantly associated with better performance on the Proverb Test, $r(101) = .34$, $p<.001$, and Digit Span, $r(100) = .24$, $p = .02$. However, SSPA role play 2 performance was not significantly related to semantic fluency, semantic infrequency, or Similarities performance, *r's* = .02-.17, *p's* >.05. In the first step of the regression model for SSPA role play 2, Stroop Word Reading and CIBS score accounted for a significant amount of variance in role play 2 performance, $F(2, 96) = 3.03$, $p = .05$, $\Delta R^2 = .06$. In the second step of the model, language accounted for a significant portion of additional variance in role play 2 performance, $F(5, 91) = 2.50$, $p = .036$, $\Delta R^2 = .11$. Proverb Test performance was uniquely associated with SSPA role play 2, $\beta = .31$, $p = .004$, in the presence of all other variables, where better performance on the Proverb Test was associated with better performance-based social functioning. However, semantic fluency, $\beta = -.024$, $p = .82$, semantic infrequency, $\beta = -.06$, $p = .59$, Similarities, $\beta = .007$, $p = .95$, and Digit Span performances, $\beta = .15$, $p = .15$, were not associated with role play 2 performance.

Results were somewhat similar for SSPA role play 3. Zero-order correlations revealed that performance on role play 3 was significantly associated with better performance on the Proverb Test, $r(101) = .37$, $p<.001$, Similarities, $r(101) = .23$, $p = .02$, and Digit Span, $r(100) = .24$, $p = .03$, but not semantic fluency, $r(100) = .18$, $p = .07$, or semantic infrequency, $r(100) = .06$, $p = .56$. In the regression model for SSPA role play

3, Stroop Word Reading and CIBS score accounted for a significant amount of variance in role play 3 performance in the first step of the model, $F(2, 96) = 5.79$, $p = .004$, $\Delta R^2 = .11$. In the second step, language performance accounted for a significant portion of additional variance in SSPA role play 3, $F(5, 91) = 2.41$, $p = .042$, $\Delta R^2 = .10$. The Proverb Test was uniquely associated with SSPA role play 3, $\beta = .30$, $p = .005$, in the presence of all other variables, where better performance on the Proverb Test was associated with better performance-based social functioning. However, semantic fluency, $\beta = -.032$, $p = .77$, semantic infrequency, $\beta = -.034$, $p = .73$, Similarities, $\beta = .055$, $p = .61$, and Digit Span, $\beta = .11$, $p = .31$, were not associated with role play 3 performance.

Exploration of Mediating Variables

Correlational analyses among planned mediation model variables are reported in Table 8. Using the averaged z-scores, better language performance was significantly associated with better social functioning, $r(99) = .33$, $p < .001$, and better social cognition, $r(97) = .46$, $p < .001$, but was unrelated to interpersonal schizotypal traits, $r(99) = -.19$, $p = .06$. Better social functioning was significantly associated with fewer interpersonal traits, $r(100) = -.46$, $p < .001$ and better social cognition, $r(98) = .41$, $p < .001$. The first exploratory mediational model did *not* suggest that the relationship of language performance to social functioning was mediated by interpersonal traits. There was no significant relationship between language and interpersonal traits, $F(1, 98) = 3.73$, $p = .06$, $R^2 = .04$, but better language performance was related to better social functioning, $F(1, 97) = 11.57$, $p = .001$, $R^2 = .11$. Controlling for language, fewer interpersonal schizotypal traits were significantly related to better social functioning, $F(2, 96) = 17.25$,

$p<.001$, $R^2 = .26$. There was no significant indirect effect of language performance on social functioning through interpersonal traits, $\beta = .08$, 95% CI [-.001, .17]. See Figure 1.

Table 8

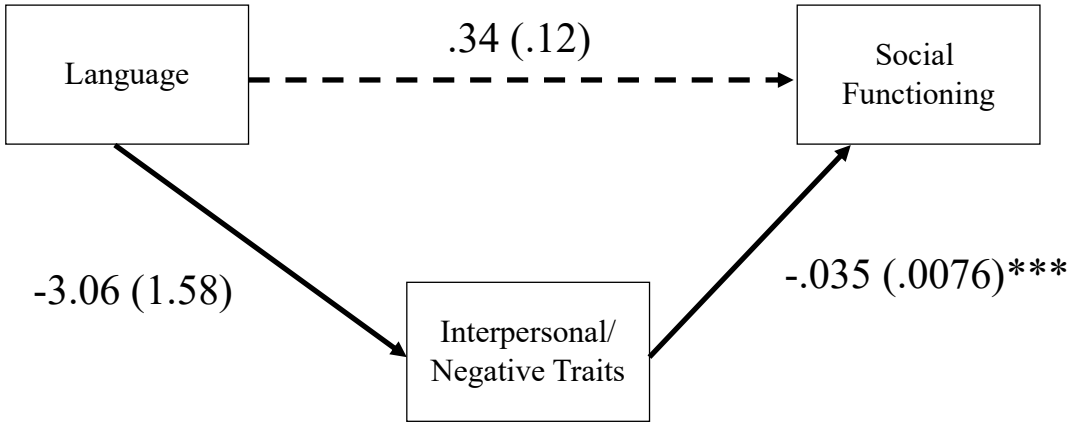
Correlational Analyses among Planned Mediation Model Variables

	1.	2.	3.	4.
1. Language z-score	--			
2. Social Functioning z-score	.33***	--		
3. Social Cognition z-score	.46***	.41***	--	
4. Interpersonal Schizotypal Traits	-.19	-.46***	-.17	--

Note. ***$p<.001$, **$p<.01$, *$p<.05$.

Figure 1

The Indirect Relationship of Language to Social Functioning through Interpersonal/ Negative Traits

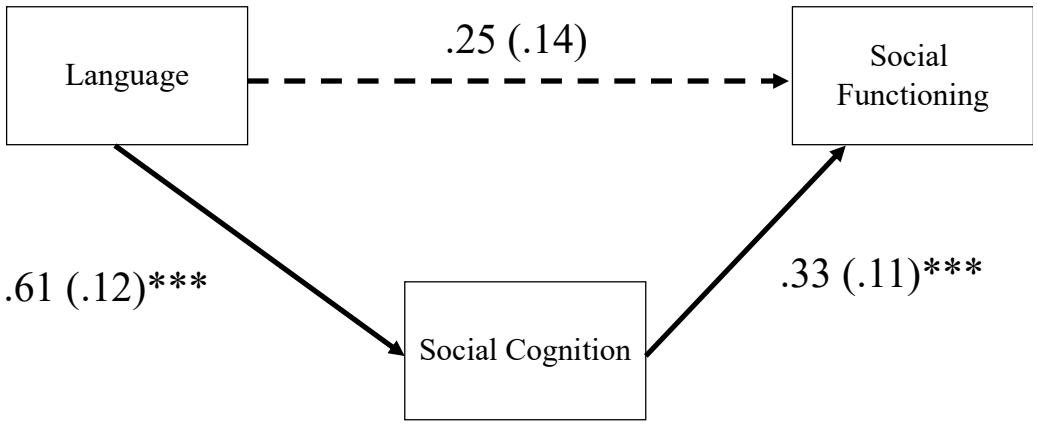


The non-significant indirect effect of language performance on social functioning through interpersonal/negative traits, $\beta = .08$, $SE = .04$, 95% CI [-.001, .17]. Unstandardized coefficients (SE) are reported for each path, where ***$p \leq .001$.

However, the second exploratory mediational model suggested that language performance was indirectly related to social functioning through social cognition. Better language performance was significantly related to better social cognition, $F(1, 95) = 25.92$, $p<.001$, $R^2 = .21$, and better language performance was significantly related to better social functioning, $F(1, 95) = 11.73$, $p = .001$, $R^2 = .11$. Controlling for language performance, better social cognition was significantly associated with better social functioning, $F(2, 94) = 11.25$, $p<.001$, $R^2 = .19$. Further, language performance was no longer related to social functioning in the presence of social cognition, $B = .26$, $t(95) = 1.73$, $p = .09$. In examining our indirect effect, better language performance was significantly related to better social functioning through social cognition, $\beta = .15$, $SE = .06$, 95% CI [.04, .27]. See Figure 2.

Figure 2

The Indirect Relationship of Language to Social Functioning through Social Cognition



The *significant* indirect effect of language performance on social functioning through social cognition, $\beta = .15$, $SE = .06$, 95% CI [.04, .27]. Unstandardized coefficients (SE) are reported for each path, where ***$p \leq .001$.

Discussion

Findings partially supported our hypothesis that the high schizotypy and FEP groups would show poorer performance on tasks of language and social functioning. With regard to language, performance on semantic fluency and the Proverb Test differed by group, after controlling for Stroop Word Reading.

The FEP group generated significantly fewer responses on semantic fluency than the low schizotypy controls, with a large effect size detected. However, there was no significant difference in responses generated between the high schizotypy and low schizotypy groups, with a small sized effect detected. There was also no difference between the FEP and high schizotypy groups, though we detected a medium sized effect between the two groups.

Prior research somewhat supports our semantic fluency findings. For example, several existing studies have found that those who recently experienced a FEP generate fewer words relative to unaffected controls, with large effect sizes observed across studies (Hwang et al., 2019; Kravariti et al., 2009, Riley et al., 2000). Further, prior studies of schizotypy found no significant difference in the number of words generated between high and low schizotypy groups (Chun et al., 2013; Minor et al., 2011). Thus, the results of our quantitative (i.e., total words generated) analyses of semantic fluency are similar to those observed in other studies.

However, across the psychotic spectrum, prior work demonstrates that those high in schizotypal traits produce more atypical semantic content when compared to those low in schizotypal traits (Angers et al., 2021; Kiang & Kutas, 2006; Minor et al., 2011). At

least one study also found that those who recently experienced a FEP also produced more atypical semantic content relative to control participants (Giovannetti et al., 2003). One reason our atypical semantic content results may differ from other studies is that we combined performances across several semantic fluency tests, whereas most other studies typically only report findings from one category, most often animals. In addition, we controlled for verbal processing speed (Stroop Word Reading) while most other studies do not. It is possible that processing speed contributes to the group differences observed in prior work. Overall, the pattern of our semantic fluency findings is consistent with the theory that language deficits in PSDs arise from executive deficits versus faulty semantic memory connections (Kuperberg, 2010), as our quantitative but not content-based findings were significant. Indeed, some scientists conceptualize quantitative scoring of semantic fluency to be related to executive skills (Heaton et al., 2004).

On the Proverb test, the FEP group performed significantly worse than the low schizotypy group, with a large effect size observed. Although the high schizotypy group also scored lower on the Proverb Test than the low schizotypy group, with a medium sized effect, the difference was not statistically significant. Interestingly, the FEP and high schizotypy group were not significantly different, and we detected a small effect size between the two groups. These results further support the idea that language deficits in PSDs may be more related to executive versus semantic skill.

Pawelczyk and colleagues (2019) observed a somewhat similar pattern of findings when comparing performance on higher-order language skills (e.g., metaphor interpretation) across an unaffected control group, an ultra-high risk for psychosis group

(UHR; i.e., experiencing attenuated psychotic symptoms; brief intermittent psychotic syndrome; or a substantial drop in social and role functioning and had a first-degree family history of a PSD or schizotypal personality disorder), and a first episode of schizophrenia group. Pawelczyk et al. (2019) found that controls performed best on higher-order language skills, UHR individuals performed worse than controls, and the first episode group performed significantly worse than both groups. Collectively, prior work and the current results provide some support that proverb interpretation and/or verbal abstract reasoning could serve as a possible endophenotype for FEP. Furthering that point, in a follow-up study, Pawelczyk et al. (2020) observed that 25% of their UHR group converted to schizophrenia, and the converters showed impairments in metaphor explanation prior to FEP onset.

Interestingly, although the Similarities subtest also measures verbal abstract reasoning, we did not observe differences in Similarities performance across the three groups. This may be because identifying verbal similarities draws on both semantic knowledge and abstract reasoning, which further supports the theory that language deficits in PSDs are more so related to executive functioning versus semantic knowledge. In comparison, the Proverb Test involves less semantic knowledge and is a purer measure of verbal abstract reasoning. Further, although several prior studies identified differences in verbal working memory between controls and at risk and/or FEP individuals, we did not observe significant differences among our study groups. One possibility may be that working memory is relatively preserved in schizotypy samples. This appears a less likely hypothesis, as at least two meta-analytic studies have found evidence for decrements in

verbal working memory in schizotypy samples (Chun et al., 2013; Siddi et al., 2017). As noted above, another difference is that most other studies do not control for verbal processing speed. It is not entirely clear why processing speed would be related to Digit Span performance, given it is not a timed test. Yet, at least one study found moderate to high correlations between working memory and processing speed tests in psychiatric patients (Kim & Park, 2018).

Our hypothesis that the high schizotypy and FEP groups would show poorer performance on tasks of social functioning was also supported. The three groups differed in both subjective (measured via the GF: Social) and performance-based social functioning (measured via the SSPA). Post hoc analyses for subjective social functioning (GF: Social performance) indicated that the FEP group was most impaired, followed by the high schizotypy group, and then the low schizotypy group. Large effect sizes were detected among all group comparisons. On average, the low schizotypy control group was rated as having good social and interpersonal functioning, the high schizotypy group was rated as having mild problems in social and interpersonal functioning, and the FEP group was rated as having moderate impairment.

Our findings mirror prior studies demonstrating that social impairment is a core deficit of PSDs and is observed across the psychotic spectrum. Prior research has found support for subjective social impairment in individuals high in schizotypal traits (Aghvinian & Sergi, 2018; Aguirre et al., 2008; Cohen & Davis, 2009; Fonseca-Pedrero et al., 2010; Wang et al., 2018), experiencing a FEP (Bratlien et al., 2013; Couture et al., 2007; Gayer-Anderson & Morgan, 2013; Jaracz et al., 2007), and with chronic PSDs

(Harvey et al., 2019; Palumbo et al., 2015; Song et al., 2011; Velthorst et al., 2017). Other studies have identified subjective social functioning decline as a one of the most significant risk factors for conversion from at risk to FEP (Addington et al., 2017; Cornblatt et al., 2015).

To our knowledge, our study is the first to examine performance-based social functioning with schizotypy and FEP individuals in the same study. Post hoc analyses revealed that performance on SSPA role play 2, which requires participants to initiate and maintain a conversation with a new neighbor, was worse in both the FEP and high schizotypy groups relative to the low schizotypy group, to a large magnitude. This same pattern was observed in SSPA role play 3, which measures social problem solving.

In both role plays, the FEP and high schizotypy groups did not statistically significantly differ from each other in their performances, with small to medium effects observed between the two. These findings demonstrate that decrements in social functioning are objectively observed across the psychotic spectrum and further support prior findings that cite social decline as a risk factor for psychosis (Addington et al., 2017; Cornblatt et al., 2015). However, it is important to note that our study was cross-sectional and can only speak to the magnitude of group differences, but not whether social impairment is associated with risk for conversion to psychosis.

On average, participants across the three groups ranged in their performance from "somewhat good" to "very good" on the SSPA rating scale. Specifically, the low schizotypy group performed closer to "very good," the FEP group performed closer to "somewhat good," and high schizotypy performance fell in the middle. None of the

groups performed in the impaired range (“very poor” or “somewhat poor”). Therefore, we did not observe performance-based impairments in social functioning, but rather relative decrements in performance-based social functioning.

In Aim 2, we found partial support for our hypothesis that language skills would be related to social functioning. We observed modest (but statistically significant) correlations between GF: Social ratings and performances on semantic fluency and the Proverb Test. However, after controlling for Stroop Word Reading performance (verbal processing speed) and CIBS score (COVID-19 distress), language was not associated with subjective social functioning as measured via the GF: Social. In contrast, we found small but significant associations between performances on SSPA role plays and the Proverb Test, Similarities, and Digit Span. Hierarchical linear regression models demonstrated that Proverb Test performance was uniquely associated with SSPA performance, after controlling for the aforementioned covariates. Consistent with our performance-based findings, a meta-analysis conducted in PSDs demonstrated that better performance on language and verbal-based tasks is associated with better social problem-solving and social skills (Halverson et al., 2019).

Given that only Proverb Test performance was uniquely associated with performance-based social functioning, we postulate that verbal abstract reasoning skills are likely related to one’s ability to identify similar interests and resolve social conflicts. These social skills underlie successful conversations and relationships. One study in UHR individuals also observed a relationship between verbal abstract reasoning and social functioning (Pawelczyk et al., 2021). In that study, better performance on higher order

language skills was significantly associated with better performance on the Social and Occupational Functioning Assessment Scale (SOFAS), an examiner-rated measure of social functioning similar to the GF: Social.

This finding differs slightly from that of the present study in that it supports our correlational but not regression findings. The additional focus on occupational functioning in the SOFAS may account, at least in part, for the differences in findings observed between Pawelczyk et al. and the current results. Moreover, their sample was comprised of only UHR individuals, which differs from the present study. Additionally, they only examined bivariate correlations to measure associations between language and social functioning, rather than assessing for unique contributions via regression analyses.

At least one prior study also found that proverb interpretation was related to performance-based but not subjective functioning in individuals with schizophrenia. Kiang et al. (2007) found that better performance on the Proverb Test was strongly related to better performance on the UCSD Performance-Based Skills Assessment (UPSA), which measures everyday (not solely social) functioning. In contrast, the authors did not find a significant association between Proverb Test performance and the Global Assessment of Functioning (GAF), an examiner-rated assessment of everyday functioning. As a possible explanation, the authors speculated that the GAF was less indicative of deficits in functional skills than the UPSA (Kiang et al., 2007).

The same may be true of our study, which relied on participant insight and report of their social functioning on the GF: Social, compared to direct observation of their social skills functioning on the SSPA. In the SSPA inception study, SSPA performance

was not related to self-reported social functioning in a sample of patients with schizophrenia (Patterson et al., 2001). In the present study, we detected moderate correlations between the SSPA role plays and GF: Social ratings, suggesting that there are subtle differences between performance-based and subjective social functioning. These data provide support for a discrepancy between subjective and objective social functioning and suggest that future studies examining social impairment should utilize both types of assessment.

In Aim 3, we investigated exploratory mediation models to discern whether well-supported mediating mechanisms identified in the chronic PSD literature held true in our at risk and early intervention sample. We did not find support for our first model, which examined whether language was related to social functioning through negative/ interpersonal schizotypal traits. Most prior mediational models tested the relationship between neurocognition and functional outcomes broadly, using negative symptoms as the mediator (see Ventura et al., 2009 for a review). Therefore, it may be that negative symptoms are more strongly related to other facets of neurocognition and functioning.

One recent review indicated that positive and disorganized symptoms in PSDs are related to executively-mediated and verbal tasks and to social functioning (Oeztuerk et al., 2021). These findings suggest that the cognitive-perceptual and/or disorganized SPQ factors may also serve as mediators. In supplemental analyses, we tested these alternative models (reported in Appendix B) and found that language was indirectly related to social functioning through cognitive-perceptual traits, but not disorganized traits. These findings are somewhat consistent with other work that demonstrates a relationship

between language and cognitive-perceptual but not negative/interpersonal traits (Angers et al., 2021; Minor & Cohen, 2012). Given we did not hypothesize these relationships a priori, these findings should be replicated.

We found support for our second exploratory model, which showed that language is indirectly related to social functioning through social cognition. Several seminal works and published reviews find that social cognition mediates the relationship between general neurocognition and social functioning in FEP and chronic PSDs (Addington et al., 2006, 2010; Green & Horan, 2010; Halverson et al., 2019; Schmidt et al., 2011). However, limited literature exists examining the relationship between language, social cognition, and social functioning. We measured social cognition via the Hinting Task and Affect Naming. Successful performance on the Hinting Task requires that participants apply verbal abstract reasoning skills to a social problem in order to make an inference as to what was meant during an example of indirect speech. Given some shared features between the verbal abstract reasoning skills required for the Proverb Test and the Hinting Test, we expected that language and social cognition would be related to one another; we found support for this relationship in our mediation model.

Further, many studies find that better social cognition is related to better social functioning across the psychotic spectrum (Combs et al., 2012; Halverson et al., 2019; Harvey & Penn, 2010; Harvey et al., 2019). Consistent with prior work, we also found strong support for a relationship between social cognition and social functioning. It is therefore not surprising that we detected an indirect effect of language on social functioning through social cognition, as verbal abstract reasoning was related to social

skills and problem solving in Aim 2, and social cognition applies verbal abstract reasoning to a social context. To the author's knowledge, our study is the first to investigate this specific relationship in an at risk and early intervention sample.

The present study has several strengths. First, we utilized a more comprehensive battery of language measures, rather than relying on overall neurocognition. Second, we measured both subjective and objective social functioning, rather than only subjective social functioning, which has been employed in most other studies. Third, we examined performance across the psychotic spectrum. Although some literature exists examining individuals who are at clinically-high risk or UHR for psychosis and FEP, very few studies have compared individuals high in schizotypy to FEP individuals. Additionally, to our knowledge, no studies to date have examined the relationship between language and social functioning, including potential mediation mechanisms, across samples of individuals high and low in schizotypal traits and those who recently experienced a FEP.

The present study also has limitations. Our sample was comprised of high functioning individuals, most of whom had completed some college and, on average, performed low average or better across language measures. Thus, our sample may not reflect other community and/or impaired populations. Our sample was also predominantly White and relatively well educated. Thus, our results may not generalize to individuals of other racial, ethnic, or educational backgrounds. Moreover, our sample of FEP individuals was comparatively much smaller than our schizotypy groups, and we may have been underpowered to detect differences between our high schizotypy and FEP groups. For example, although we detected medium sized effects when examining the

relationship between the high schizotypy and FEP groups on semantic fluency and SSPA role play performance, and between the high and low schizotypy groups on the Proverb test, these comparisons were not statistically significant. As such, findings do suggest that there may be potentially meaningful differences among the three groups that should be further examined in larger samples. It should also be noted that our study was conducted virtually due to the ongoing COVID-19 pandemic; thus, all study tasks were administered in a different format than they were originally created and normed. This is particularly interesting for the social functioning tasks, in which virtual administration may have reduced social demands required in in-person settings. Last, our data is cross-sectional in nature. Therefore, it is unclear whether these findings would hold true over time, and we cannot draw any causal relationships from our analyses.

Future studies should examine these relationships over time to further examine the relationship of language and social functioning across the psychotic spectrum. Incorporation of UHR samples may help to further discern differences in language and social functioning across the psychotic spectrum. Given our findings suggested that executively-mediated language tasks were uniquely associated with social functioning, future studies may incorporate other executively-demanding language measures, such as phonemic fluency, to further elucidate this relationship. Further, many machine learning analyses of speech samples find that language abnormalities reliably predict psychosis onset (see Corcoran et al., 2020 for a review). Thus, comparing well-validated clinical measures of language to machine learning analyzed speech samples may benefit our understanding of language deficits innate to the psychotic spectrum.

In conclusion, to the author's knowledge, the present study is the first to examine the relationship of language to social functioning across the psychotic spectrum, utilizing individuals high and low in schizotypal personality traits and those who recently experienced FEP. Our findings suggest that executively-mediated language tasks and social cognition may be beneficial targets of intervention for social impairment. Future research should aim to replicate the present findings in longitudinal models, which would strengthen the present findings.

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Appendix A

All tests were administered in a standard sequenced order: informed consent, demographics, SPQ, CIBS, SSPA, GF: Social - traditional, GF: Social - COVID-19, WAIS-IV Vocabulary, WAIS-IV Similarities, DKEFS Proverb Test, Semantic Fluency Tests, Stroop Word Reading, WAIS-IV Digit Span, Hinting Task, and Affect Naming. Note that additional measures were administered as part of the larger study but only those relevant to study hypotheses are detailed in the present dissertation. The following non-copyrighted measures are available for review: Demographics, SPQ, Semantic Fluency Tests, Gf: Social, CIBS.

Demographics

What county are you participating from?

Please select today's date.

What is your current age? ___

What was your sex assigned at birth?

1. Female 2. Male

What would you describe as your gender identity?

1. Female 2. Male 3. Trans male 4. Trans female 5. Gender queer/Gender non-conforming

What would you describe your race/ethnicity?

1. Asian American/Pacific Islander 2. American Indian/Alaskan Native 3. Black/African American 4. Hispanic/Latino(a)(x) 5. White 6. Multi-racial/Other

What is the highest level of education you have received? ____

Who do you live with?

1. Alone 2. With family 3. With friends 4. With roommates 5. Other

Personal Medical History

1. Have you ever had a head injury resulting in loss of consciousness for 30 minutes or greater? Yes, No
2. Have you ever been **diagnosed** with a seizure disorder?

   Yes, No
3. Have you ever been **diagnosed** with a brain disease or disorder?

   Yes, No

4. Have you ever been **diagnosed** with a learning disability?

   Yes, No

5. Have you ever been **diagnosed** with a ADHD?

   Yes, No

6. Have you ever been **diagnosed** with depression?

   Yes, No. If so, what symptoms did you experience? When were you diagnosed? Did you receive treatment? Have you ever been hospitalized as a result of depression?

7. Have you ever been **diagnosed** with bipolar disorder?

   Yes, No. If so, what symptoms did you experience? When were you diagnosed? Did you receive treatment? Have you ever been hospitalized as a result of bipolar disorder?

8. Have you ever been **diagnosed** with schizophrenia?

   Yes, No. If so, what symptoms did you experience? When were you diagnosed? Did you receive treatment? Have you ever been hospitalized as a result of schizophrenia

9. Have you ever been **diagnosed** with schizoaffective disorder?

   Yes, No. If so, what symptoms did you experience? When were you diagnosed? Did you receive treatment? Have you ever been hospitalized as a result of schizoaffective disorder?

10. Have you ever been **diagnosed** with a substance use disorder (alcohol, marijuana, cocaine, opiates, etc)?

    Yes, No. If so, what symptoms did you experience? When were you diagnosed? Did you receive treatment? Have you ever been hospitalized as a result of substance use disorder?

11. Have you ever been **diagnosed** with anxiety?

    Yes, No. If so, what symptoms did you experience? When were you diagnosed? Did you receive treatment? Have you ever been hospitalized as a result of anxiety?

12. Have you ever been **diagnosed** with post-traumatic stress disorder?

    Yes, No. If so, what symptoms did you experience? When were you diagnosed? Did you receive treatment? Have you ever been hospitalized as a result of post-traumatic stress disorder?

SPQ (Davidson et al., 2016)

item #	Text
1	I sometimes feel that people are talking about me.
2	I sometimes feel that other people are watching me.
3	When shopping, I get the feeling that other people are taking notice of me.
4	I often feel that others have it in for me.
5	I sometimes get concerned that friends or co-workers are not really loyal or trustworthy.
6	I often have to keep an eye out to stop people from taking advantage of me.
7	I feel that I cannot get 'close' to people.
8	I find it hard to be emotionally close to other people.
9	I feel that there is no one I am really close to outside of my immediate family, or people I can confide in or talk to about personal problems.
10	I tend to keep my feelings to myself.
11	I rarely laugh and smile.
12	I am not good at expressing my true feelings by the way I talk and look.
13	Other people see me as slightly eccentric (odd).
14	I am an odd, unusual person
15	I have some eccentric (odd) habits.
16	People sometimes comment on my unusual mannerisms and habits.
17	I often feel nervous when I am in a group of unfamiliar people.
18	I get anxious when meeting people for the first time.
19	I feel very uncomfortable in social situations involving unfamiliar people.
20	I sometimes avoid going to places where there will be many people because I will get anxious.
21	I believe in telepathy (mind-reading).
22	I believe in clairvoyance (psychic forces, fortune telling).
23	I have had experiences with astrology, seeing the future, UFO's, ESP, or a sixth sense.
24	I have felt that I was communicating with another person telepathically (by mind-reading).
25	I sometimes jump quickly from one topic to another when speaking.
26	I tend to wander off the topic when having a conversation.
27	I often ramble on too much when speaking.
28	I sometimes forget what I am trying to say.
29	I often hear a voice speaking my thoughts aloud.
30	When I look at a person or at myself in a mirror, I have seen the face change right before my eyes.
31	My thoughts are sometimes so strong that I can almost hear them.
32	Everyday things seem unusually large or small.

Response format: 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree

Semantic Fluency Tests

"Now I want you tell me as many animals as you can think of. They can start with any letter, you'll have 60 seconds. Begin."

"We'll do the same thing again, this time your category is Vegetables. Begin."

"We'll do the same thing again, this time your category is Fruits. Begin."

"We'll do the same thing again, this time your category is Action words such as kick and run. Begin.

GF: Social (Cornblatt et al., 2007, Appendix 1)

"Specific questions to aid in rating the GF: Social scale are provided below. Be sure to assess for changes in social functioning over the previous year (to rate highest and lowest) as well as current functioning in the past month.

Tell me about your social life. Do you have friends?

Are they casual or close friends? If only casual—are they school or work friends only? If close—how long have you been close friends?

How often do you see friends? Do you see them outside of work/school? When was the "last time" you saw one of your friends outside of work/school? (Attempt to determine "actual" amount of social contact vs perceived amount of social contact.)

Do you usually initiate contact or activities with friends or do they typically call or invite you? Do you ever avoid contact with friends?

Do you ever have problems/falling outs with friends? Arguments or fights?

Are you dating or interested in dating? (Alter as needed to assess age-appropriate intimate relationships)

Do you spend time with family members (at home)? How often do you communicate with them? Do you ever avoid contact with family members?

Superior social/interpersonal functioning

10 Superior functioning in a wide range of social and interpersonal activities. Frequently seeks out others and has multiple satisfying interpersonal relationships, including multiple close and casual friends. Is sought out by others because of his or her many positive qualities. Age-appropriate involvement in intimate relationships.

Above average social/interpersonal functioning

9 Good functioning in all social areas, and interpersonally effective. Interested and involved in a wide range of social and interpersonal activities, including both close and casual friends. Age-appropriate involvement in intimate relationships. No more than everyday interpersonal problems or concerns (eg, an occasional argument with spouse, girlfriend/boyfriend, friends, coworkers, or classmates). Able to resolve such conflicts appropriately.

Good social/interpersonal functioning

8 Some transient mild impairment in social functioning. Mild social impairment is present, but transient and expectable reactions to psychosocial stressors (eg, after minor arguments with spouse, girlfriend/boyfriend, friends, coworkers, or classmates). Has some meaningful interpersonal relationships with peers (casual and close friends), and/or age-appropriate intimate relationships. Infrequent interpersonal conflict with peers.

Mild problems in social/interpersonal functioning

7 Some persistent mild difficulty in social functioning. Mild impairment present that is NOT just expectable reaction to psychosocial stressors (eg, mild conflicts with peers, coworkers or classmates; difficulty resolving conflicts appropriately). Has some meaningful interpersonal relationships with peers (casual and/or close friends). Some difficulty developing or maintaining age-appropriate intimate relationships (eg, multiple short-term relationships).

Moderate impairment in social/interpersonal functioning

6 Moderate impairment in social functioning. Moderate impairment present (eg, few close friends; significant but intermittent conflicts with peers, coworkers, or classmates). Moderate difficulty developing age-appropriate intimate relationships (eg, infrequent dating). Occasionally seeks out others but will respond if invited by others to participate in an activity.

Serious impairment in social/interpersonal functioning

5 Serious impairment in social functioning. No close friends or intimate partner but has some casual social contacts (eg, acquaintances, school/work friends only). Rarely seeks out others. Occasional combative or verbally argumentative behavior with peers. Beginning to withdraw from family members (eg, does not initiate conversation with family, but will respond if addressed).

Major impairment in social and interpersonal functioning

4 Major impairment in social functioning. Serious impairment in relationships with friends or peers (eg, very few or no friends, frequent conflicts with friends, or frequently avoids friends). Frequent combative or verbally argumentative behavior with peers. Infrequent contact with family members (eg, sometimes does not respond to family or avoids family members).

Marginal ability to function socially

3 Marginal ability to function socially or maintain interpersonal relationships. Frequently alone and socially isolated. Serious impairment in relationships with all peers, including acquaintances. Few interactions with family members (eg, often alone in

room). Serious impairment in communication with others (eg, avoids participating in most social activities).

Inability to function socially

2 Unable to function socially or to maintain any interpersonal relationships. Typically alone and socially isolated. Rarely leaves home. Rarely answers the phone or the door. Rarely participates in interactions with others at home or in other settings (eg, work, school).

Extreme social isolation

1 Extreme social isolation. No social or family member contact at all. Does not leave home. Refuses to answer the phone or door.

Note: This scale has been partially derived from the Social and Occupational Functioning Assessment Scale (SOFAS) from Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) and the GAF as it appears in the Scale of Prodromal Symptoms (SOPS). Item content has been changed to focus specifically on social and interpersonal functioning" (pp. 697-699).

CIB-S (Schmidt et al., 2021)

Think back over the past 30 days and answer these questions using the given scale.

1. I worry I will be unable to provide for my family during this time of COVID-19

Not at all (0) Very Little (1) Some (2) Much (3) Very Much (4)

2. I worry that if I go into quarantine, I will go crazy

Not at all (0) Very Little (1) Some (2) Much (3) Very Much (4)

3. I worry that I am going to contract COVID-19

Not at all (0) Very Little (1) Some (2) Much (3) Very Much (4)

4. Taking care of household responsibilities

Not at all (0) Very Little (1) Some (2) Much (3) Very Much (4)

5. Concentrating on doing something for ten minutes?

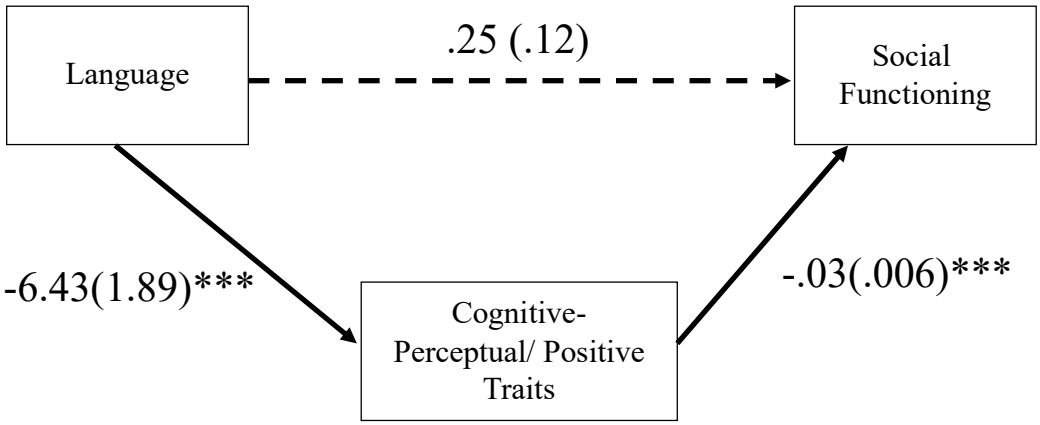
Not at all (0) Very Little (1) Some (2) Much (3) Very Much (4)

Appendix B

We conducted supplemental mediational analyses to determine whether language was indirectly related to social functioning through cognitive-perceptual/positive and/or disorganized schizotypal traits. Correlational analyses revealed that endorsing more cognitive-perceptual traits was significantly associated with worse language performance, $r(99) = -.33$, $p<.001$, and worse social functioning, $r(100) = -.49$, $p<.001$. Our first supplemental mediation analysis investigated whether language was indirectly related to social functioning through cognitive-perceptual/positive traits. We found support for this model. Better language performance was significantly related to fewer cognitive-perceptual traits, $F(1, 97) = 11.53$, $p = .001$, $R^2 = .11$, and better language performance was significantly related to better social functioning, $F(1, 97) = 11.27$, $p = .001$, $R^2 = .11$. Controlling for language performance, fewer cognitive-perceptual traits were significantly associated with better social functioning, $F(2, 96) = 17.79$, $p<.001$, $R^2 = .27$. When examining our indirect effect, better language performance was significantly related to better social functioning through cognitive-perceptual traits, $\beta = .14$, $SE = .05$, 95% CI [.06, .23]. See Figure 3.

Figure 3

The Indirect Relationship of Language to Social Functioning through Cognitive-Perceptual/Positive Traits



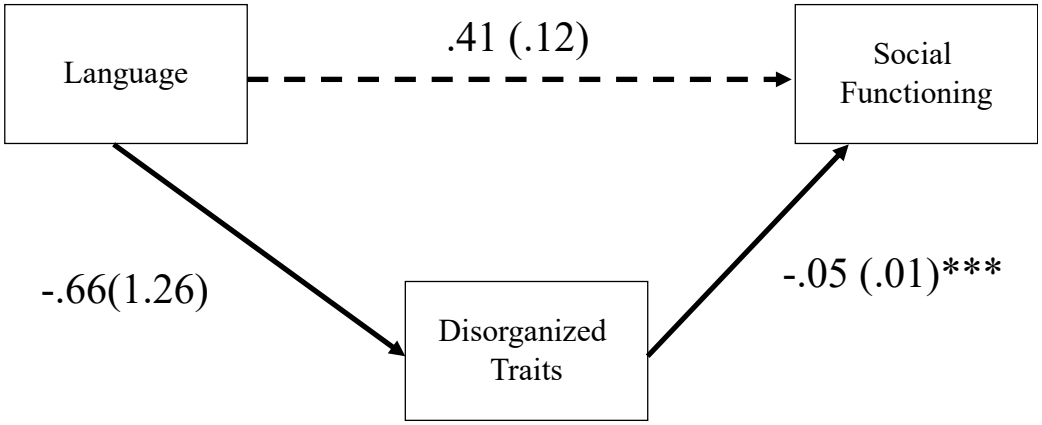
The *significant* indirect effect of language performance on social functioning through cognitive-perceptual/positive traits, β = .14, *SE* = .05, 95% CI [.06, .23]. Unstandardized coefficients (SE) are reported for each path, where ***$p \leq .001$.

Our second supplemental mediation analysis investigated whether language was indirectly related to social functioning through disorganized traits. Correlational analyses revealed that endorsing more disorganized traits was significantly associated with worse social functioning, $r(100) = -.44$, $p < .001$, but was unrelated to language performance, $r(99) = -.05$, $p = .60$. Our second supplemental mediation analysis did find not support for an indirect relationship of language to social functioning through disorganized traits. There was no significant relationship between language and disorganized traits, $F(1, 97) = .27$, $p = .60$, $R^2 = .004$, but better language performance was related to better social functioning, $F(1, 97) = 11.57$, $p = .001$, $R^2 = .11$. Controlling for language, fewer disorganized schizotypal traits were significantly related to better social functioning, $F(2,$

96) = 18.38, p<.001, R^2 = .28. There was no significant indirect effect of language performance on social functioning through disorganized traits, β = .02, 95% CI [-.075, .12]. See Figure 4.

Figure 4

The Indirect Relationship of Language to Social Functioning through Disorganized Traits



The non-significant indirect effect of language performance on social functioning through disorganized traits, β = .02, 95% CI [-.075, .12]. Unstandardized coefficients (SE) are reported for each path, where ***$p \leq$.001.

Our study found evidence that cognitive-perceptual/positive schizotypal traits served as a significant mediator between language performance and social functioning across the psychotic spectrum, while interpersonal (see Results and Discussion) and disorganized traits did not. This stands in contrast to other and more robust findings that negative symptoms mediate the relationship between neurocognition broadly and social functioning in PSDs (see Ventura et al., 2009 for a review).

One possible explanation is that our study examined language specifically, rather than neurocognition broadly, as has been done in prior research. It is possible that cognitive-perceptual traits may be more related to language ability. Formal thought disorder (FTD) is a condition that occurs in psychosis and results in loose associations, thought blocking, paraphasia, and language and communication deficits. Some scientists have classified delusions, which are related to positive/cognitive-perceptual traits, as a type of thought disorder and a byproduct of abnormal speech content (Roche et al., 2015). This may explain why our findings showed that more cognitive-perceptual traits were related to worse language performance. Moreover, review studies find that FTD symptoms are most related to executively-mediated and verbal-based tasks (Oeztuerk et al., 2021) and also to poor social functioning and outcomes across the psychotic spectrum (Oeztuerk et al., 2021; Roche et al., 2015).

Given these findings in FTD, it is somewhat surprising that disorganized traits did not also prove a significant mediator. However, the SPQ only has four items related to "Odd Speech" whereas the other four items are related to "Eccentric Behavior" (Davidson et al., 2016), potentially explaining why disorganized traits were unrelated to language in our sample. Our work provides some preliminary support for a relationship between language and social functioning through cognitive-perceptual schizotypal traits. Future work should continue to explore this relationship, and whether this relationship could be explained by symptoms of FTD.

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