Logical Reasoning Deficits and Severity of Delusional Symptomatology in Psychotic Disorders

A Thesis

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Research in psychotic disorders has recently been focused on identifying early indicators of future symptomatology. Our study aimed to establish a model for the relationship of a test of logical reasoning, moderated by belief inflexibility, for predicting delusional symptomatology. As part of the Neurodevelopment in Adolescence and Young Adulthood (NAYA) study, the Penn Computerized Neurocognitive Battery (CNB) was administered to three groups: individuals with a psychotic disorder (PD) ($N = 17$), individuals at high-risk for a psychotic disorder (HR) ($N = 26$), and individuals at low-risk for a psychotic disorder (LR) ($N = 19$). The Penn Conditional Exclusion Task (PCET) was specifically examined through the use of its measures of accuracy and perseverative errors to see its predictive ability for delusional symptomatology as measured by the Scale for the Assessment of Positive Symptoms (SAPS) and the Scale of Prodromal Symptoms (SOPS) Positive Symptoms Subscale. Results indicated small to large effect sizes for group differences on PCET outcome variables, and evidence of a moderation relationship was also found for the PD and HR group tests. Possible implications of these findings are that the PCET can be used to predict the course of delusional symptomatology. The development of a psychotic symptoms scale that takes into account the range of symptoms from the prodromal to post-onset stages is necessary to accurately test such possible predictor models.
1. INTRODUCTION

1.1 Overview

Cognitive deficits are the most prevalent symptoms among those with schizophrenia and psychotic disorders (Reichenberg et al., 2009). These include impairments in such areas as verbal and facial memory (Aleman, Hijman, de Haan, & Kahn, 1999) and affect recognition (Addington, Saeedi, & Addington, 2006), visuomotor processing and attention (González-Blanch et al., 2006), and a number of other cognitive domains (O’Donnell, 2007; Chang et al., 2012). While improvements in psychotic symptoms, sometimes to the point of complete remission, can be achieved as a result of psychopharmacological and psychotherapeutic interventions, it is often after years of functional decline and multiple psychotic relapses (Friedman, Harvey, Kemether, Byne, & Davis, 1999; Ayuso-Gutiérrez & del Río Vega, 1997). During the course of illness, cognitive deficits can continue to worsen and create further impediments to successful treatment and daily functioning (Lewandowski, Cohen, & Ongur, 2011; Świtaj et al., 2012). It is in part due to this continual functional decline that recent years have seen a stronger emphasis placed on the study and treatment of the early stages of psychotic disorders, particularly the prodromal stages and first-episode psychosis (Fusar-Poli et al., 2013; Alvarez-Jiménez et al., 2011; Alvarez-Jiménez et al., 2012). With a better understanding of the stages immediately pre- and post-onset of psychosis, it may be possible to discern specifics of the mechanisms generating and maintaining PD (Holtzman et al., 2013). Treatments may be tailored to specifically target these mechanisms essential to the early course of illness in PD, allowing for better prognoses and preservation of general functioning (Hegelstad et al., 2012). However, while there is
much that is known about what is affected by the presence of PD such as schizophrenia, few specifics are known about the relative importance of these affected domains and what is central to the pathogenesis of these disorders (Tandon, Keshavan, & Nasrallah, 2008).

1.2 Interconnectedness of Delusions and Cognitive Deficits

One important aspect of PD is the observed interconnectedness of symptomatology; this is evident from research showing that cognitive deficits play a role in the maintenance of psychotic symptoms, specifically that of delusions (Adams et al., 2013). Delusions, as defined by Sims (1995), are false, irrational ideas or beliefs that are not congruent with an individual’s sociocultural background; delusions also sometimes arise from formerly valid ideas that have developed beyond the confines of reason (Kingham & Gordon, 2004). Deficits in reasoning skills have been shown to be associated with delusional conviction in psychotic disorders (PD) (So et al., 2012), including impairments in logical reasoning that have been linked to the belief inflexibility exhibited in these disorders (Speechley et al., 2010). The genetic risk of PD has been long established (Sullivan, Kendler & Neale, 2003), and both persons with a PD and their first-degree relatives have shown similar deficits across multiple cognitive domains (Calkins et al., 2009). The same is true of those at clinical-risk of PD (Keefe et al., 2006). However, the extent of the similarity of these deficits has yet to be firmly established, namely whether the mechanisms of a specific deficit are consistent in both an individual with a PD and an at-risk individual (i.e., genetic- and/or clinical-risk) (Gal et al., 2005; Simon et al., 2007; Orosz et al., 2011).
1.3 Significance of the Present Study

Prior to our hypotheses testing, the research design for the current study was constructed based upon previous research in PD, specifically schizophrenia, with the chronic, first-episode, and prodromal populations. Based upon findings that show abstraction/flexibility as one of the most stable cognitive deficits throughout schizophrenia’s course of illness and that this same belief inflexibility is a central component to the reasoning biases found to be related to delusional conviction (Albus et al., 2006; Garety et al., 2005), we selected for analysis a subtest from the Penn Computerized Neurocognitive Battery (CNB) administered as part of the Neurodevelopment in Adolescence and Young Adulthood (NAYA) (Calkins, 2007) study that focused specifically on abstraction: the Penn Conditional Exclusion Task (PCET).

Through the use of the CNB, which includes the PCET, a test of reasoning skills that also tracks logical inflexibility through perseverative errors, we aim to examine three hypotheses: first, that the high-risk (HR) group would show similar deficits in reasoning skills as reflected by poor performance on the PCET as those in the PD group when compared to the low-risk (LR) group. Second, that logical inflexibility as measured by perseverative errors on the PCET will act as an enhancing moderator variable in predicting the relationship between logical thinking accuracy as assessed by performance on the PCET and global severity of delusions for individuals in the PD group, as reflected by ratings on the Scale for the Assessment of Positive Symptoms (SAPS) (Andreasen, 1984). And third, that logical inflexibility as measured by perseverative errors on the PCET will act as an enhancing moderator variable in predicting the relationship between logical thinking accuracy as assessed by performance on the PCET and subthreshold
delusional ideation as reflected by ratings on the Scale of Prodromal Symptoms (SOPS) (Miller et al., 1999) for premorbid delusional ideation in the HR group. By examining these hypotheses, we aim to show two things: first, deficits in reasoning skills can be used to predict the strength of delusional conviction in patients with an Axis I primary psychotic disorder. And second, deficits in reasoning skills can be used to identify those at-risk for Axis I primary psychotic disorder and predict some delusion-related aspects of the course of their illness.

2. METHODS

2.1 Participants

Subject were drawn from those that participated in the Neurodevelopment in Adolescence and Young Adulthood (NAYA) (Calkins, 2007) study and included patients with a current psychotic disorder (N = 17; 10 males; mean age 21±3.2 years); individuals at high-risk for a psychotic disorder (N = 26; 11 males; mean age 19±3.5 years), which consisted of both clinical-risk (n = 12) and genetic-risk (n = 14) individuals; and a low-risk control group (N = 19; 8 males; mean age 21±2.0 years). All participants were diagnosed by clinical interview using the Diagnostic Interview for Genetic Studies (DIGS) (Nurenberg et al., 1994) and Structured Interview for Prodromal Syndromes (SIPS) (Miller et al., 2003) (see Table 1 in Appendix C for complete demographics).

Participants had to be between age 10 to 25 years at the time of the study to be eligible for inclusion. Participants were excluded if they met any of the following criteria: 1) presence or history of pervasive developmental disorder or mental retardation by DSM-IV-TR criteria 2) presence or history of medical or neurological disorder that may affect brain function, including hypertension, cardiac disease, endocrine disorders, renal
disease, pulmonary disease, history of seizures or head trauma or CNS tumors 3) not proficient in English 4) non-completion of the Penn Computerized Neurocognitive Battery (CNB) procedures.

2.1.1 Psychotic Disorder Participants

The inclusion criteria for the Psychotic Disorder (PD) group were the following: 1) a current diagnosis of a psychotic disorder according to DSM-IV-TR criteria 2) no first- or second-degree biological relative enrolled in the high-risk group.

2.1.2 High-Risk Participants

Individuals included in the High-Risk (HR) group had to meet one of the following criteria: 1) currently experiencing prodromal symptoms, but no DSM-IV-TR Axis I psychotic disorders (i.e., clinical risk) 2) first-degree relatives of individuals with a psychotic disorder (i.e., genetic risk) 3) both of the previous two criteria (i.e., genetic-clinical risk). Prodromal symptoms were operationally defined as at least one positive symptom rated 3, 4, or 5, OR at least two negative and/or disorganized symptoms rated 3, 4, 5, or 6, on the Scale of Prodromal Symptoms (SOPS).

While the NAYA study from which we drew our participants included family members due to a within-family analysis component, we chose to look specifically at the diagnostic groups as a whole; therefore, whenever both a PD individual and HR individual were eligible for inclusion in our study but came from the same family, the PD individual was excluded due to the smaller overall numbers of the HR group. By uniformly excluding the PD individual in these instances, non-independence was avoided. Our study also combined the NAYA study’s original groups of Genetic Risk and
Clinical Risk into a single High Risk group due to the low sample size of individuals eligible for inclusion in this study and the lack of any planned analysis comparing Genetic Risk and/or Clinical Risk groups.

2.1.3 Low-Risk Participants

The inclusion criteria for the Low-Risk (LR) group were the following: 1) no family history of psychosis in a first- or second-degree biological relative 2) no prodromal symptoms as described 3) no DSM-IV-TR Axis I psychotic disorder or Axis II Cluster A diagnoses 4) comparable in age, sex, and socioeconomic status to PD and HR group individuals. LR group participants were excluded if they met either of the following criteria: 1) presence or history, in the subject, of the previously mentioned DSM-IV-TR Axis I or Axis II disorders 2) presence or history, in the subject’s first- or second-degree relatives, of a DSM-IV-TR psychotic disorder. Self-report was used to determine eligibility for the LR group based upon the previously mentioned criteria.

2.2 Materials

Data was acquired through the NAYA (Calkins, 2007) study, a longitudinal investigation of risk factors in youths judged at high risk of developing psychosis. Basic demographic information was obtained via participant self-report; this included age, sex, race, ethnicity, highest level of education completed, parental education level, and the duration of illness. All information was collected prior to scale administration.
2.2.1 Penn Conditional Exclusion Test (PCET)

This particular subtest of the Penn Computerized Neurocognitive Battery (CNB) is a measure of abstraction. Participants are presented with a set of four objects that differ on three different features: line thickness, shape, and size. Without being told which of the three features to use as the basis for discrimination, the participant is asked to select which of the four objects does not belong. Correctly selecting the object that does not belong results in the word “correct” flashing across the screen, while incorrect responses result instead in the word “incorrect”. This feedback is intended to assist the participant in deducing the feature to use for discrimination. If the participant responds incorrectly two consecutive times, this is counted as a perseverative error. After a certain number of consecutive correct responses, the feature used as the basis for discrimination changes (i.e., task moves from “Category 1” to “Category 2”) without informing the participant in any way other than the previously mentioned feedback. By abruptly changing the task rules without informing the participant and then providing feedback for subsequent responses that is contradictory to the participant’s current understanding of the task’s rules, thought flexibility is assessed. If a long string of erroneous responses occurs, the participant effectively “fails out” of the task and the subtest ends.

There are two variables of particular interest collected during the PCET: the first is Accuracy (ACC), which has been calculated with the following mathematical equation:

\[
ACC = \frac{Total\ Correct\ Responses}{(Total\ Correct\ Responses + Total\ Incorrect\ Responses)}
\]
The second is Perseverative Errors (PER), which is the total number of times two erroneous responses have sequentially occurred. Two errors in a row would count as one perseverative error, three would count as two, four would count as three, etc. A third variable that was also examined is Efficiency (EFF), calculated using the following equation:

\[
EFF = \frac{ACC}{\log(\text{Response Time for Correct Responses})}
\]

2.2.2 Scale for the Assessment of Positive Symptoms (SAPS)

The SAPS was developed to assess the positive symptoms that occur in schizophrenia (Andreasen, 1984). It consists of 31 questions divided into four subscales: Hallucinations, Delusions, Bizarre Behavior, and Positive Formal Thought Disorder. Symptoms are rated on a six-point Likert scale, with “0” meaning that no signs of the symptom are present and “6” meaning the symptom is almost constantly present, pervasive and severe. These ratings represent the past month of symptoms and are based upon responses given to a clinical interview as well as supplementary sources of information, such as corroborating reports from family members and/or mental health professionals that regularly interact with the individual being assessed. The final rating on each subscale represents the overall global rating of that specific type of positive symptomatology; for the current study, we focused on using the overall global rating for the “Delusions” subscale. The Delusions subscale of the SAPS has shown to be a valid measure of an individual’s preoccupation with and conviction to delusions (Steel et al., 2007).
2.2.3 Scale of Prodromal Symptoms (SOPS)

Contained within the Structured Interview for Prodromal Syndromes (SIPS), the SOPS is designed to measure the presence and severity of each prodromal syndrome to inform the prodromal diagnosis (Miller et al., 1999). It consists of four subscales assessing the different domains of symptoms: Positive Symptoms, Negative Symptoms, Disorganization Symptoms, and General Symptoms. All subscale items are rated on a scale ranging from “0” (Never, Absent) to “6” (Severe/Extreme – and Psychotic, for those items on the Positive Symptoms subscale). Within the Positive Symptoms subscale, scores in the “3” to “5” range are indicative of those in the prodromal stage, while those at “6” are considered psychotic (Miller et al., 1999). These ratings are based upon information obtained during clinical interview, as well as supplementary sources of information, such as corroborating reports from family members. Psychometric studies demonstrated that the SOPS is excellent in its total score reliability ($r = .95$) and in all subscales as well (i.e., for all subscales, $r \geq .75$); this includes excellent reliability on nearly all the individual items (Miller et al., 2003). The present study focused on the first item of the Positive Symptoms subscale, “Unusual Thought Content/Delusional Ideas” (see Appendix B); this item is closest in concept to representing the prodromal version of a global rating of delusions.

2.3 Design

This study utilizes a three-group between-groups correlational design to assess the first hypothesis, then a one-group moderated correlational design for the second and third hypotheses. In testing the first hypothesis, group membership served as the independent
variable while accuracy scores on the PCET portion of the CNB served as a dependent variable. For testing the second and third hypotheses, the dependent variables were SAPS ratings for global severity of delusions (i.e., item #20) and SOPS ratings for unusual thought content/delusional ideas (i.e., item #P1), respectively. Accuracy scores on the PCET was the independent variable, with the number of perseverative errors on the PCET set as a moderator.

The number of perseverative errors has been theorized to moderate this relationship based upon the idea that more perseverative errors indicate a lack of cognitive flexibility. The PCET begins with the presentation of four shapes coupled with an ambiguous instruction to select the item that does not belong out of four items that all could be deemed the outlier based upon one aspect of their composition. Figure 1 below shows a sample item from the PCET.

1. Sample item presentation from the PCET.
Upon repeated trials, once the individual has deduced the feature that is being used as the determinant for classification (i.e., line thickness, shape, or size), he will most often continue selecting the correct response up until the task rules abruptly change without notice to the test taker. Specifically for the PCET, the first determining feature for classification is line thickness, which then changes to shape after ten correct responses. While an individual may perform poorly on the PCET for a variety of reasons, an inability to adjust reasoning to a newly introduced, unknown set of rules may result in a higher number of perseverative errors, especially for those individuals that fail out of the task upon reaching the second category. This inability to adjust reasoning even after receiving the contradictory feedback that lets the individual know that his responses are incorrect is also seen when delusional conviction remains steadfast even when the individual is presented with information contradicting the delusion.

2.4 Procedure

Participants volunteered to participate in the NAYA project and were determined to fall into one of four categories, as previously described: psychotic, genetic risk, clinical risk, or low risk. All participants underwent a standard diagnostic assessment procedure consisting of the Diagnostic Interview for Genetic Studies (DIGS), Structured Interview of Prodromal Symptoms (SIPS), and various self-report questionnaires. These interviews were conducted by trained clinical research coordinators who have been verified as reliable by the project’s primary investigator. The same clinical research coordinator completed the post-interview rating scales of symptomatology (e.g., SOPS, SAPS, etc.).
After completing the assessment portion of the study, participants were then administered the Penn Computerized Neurocognitive Battery (CNB). The testing setup consists of a laptop with single-button mouse attached. The participant sits facing the computer with the test administrator seated behind and to the left of the participant.

Prior to administration of any procedures, written informed consent/assent was obtained. All procedures were approved by the Institutional Review Board of the University of Pennsylvania. Following the completion of all procedures for a participant, the diagnostic information is reviewed and assigned a consensus diagnosis that has been agreed upon by a board including the primary investigator and other qualified doctoral-level psychologists and psychiatrists specializing in psychotic disorders.

3. RESULTS

3.1 Preliminary Analyses

Examination of pertinent demographic information revealed that our randomly selected sample resulted in no significant group differences across basic demographic categories with the exception of education level (see Table 1 in Appendix C). However, this could be expected due to the age of onset in schizophrenia, particularly in males, often coinciding with the years an individual is still pursuing a high school or college degree (Buchanan & Carpenter, 2005).

3.2 Group Differences on PCET

A one-way ANOVA was run to examine group differences on several outcome variables of the PCET. Results indicated there were no significant group differences on
any of the tested variables. However, effect size analysis revealed medium effects for the mean differences between PD and LR groups across the variables of the PCET, as well as small effects for the mean differences between HR and LR groups on those same variables. When analyses were run using only the male participants, these effect sizes increased to large effects for the mean differences between PD and LR groups and small to medium effects for the mean differences between HR and LR groups (see Table 2 in Appendix C).

3.3 Interconnectedness of Delusions and Logical Reasoning Skills in Psychotic Disorders

Using the PD group of our sample, a moderation analysis was run with PCET total Perseverative Errors moderating the relationship between PCET Accuracy and SAPS Global Rating of Delusions. The predictor variable PCET Accuracy failed to reach a level of significance, $b = -1.13$, $t(13) = -0.91$, $p \leq .38$, $r = .24$, nor did the interaction effect, $b = -0.04$, $t(13) = 0.99$, $p \leq .34$, $r = .26$. Model analysis showed that the interaction effect did increase the variance explained by the model, but not to a significant degree, $F(1,13) = .99$, $p \leq .34$. However, at low levels of the moderator variable, the strength of the relationship between PCET Accuracy and the outcome variable SAPS Global Rating of Delusions was buffered, $b = -0.59$, $t(13) = 0.57$, $p \leq .58$, $r = .16$, while at high levels of the moderator variable, the strength of the relationship was enhanced, $b = -1.68$, $t(13) = -1.03$, $p \leq .32$, $r = .27$ (see Table 3 in Appendix D). This information was used to construct Figure 2, the visual representation of the moderation relationship seen below, illustrating that no interaction was present.
2. PD group non-interaction of Perseverative Errors and PCET Accuracy for SAPS Delusions Rating.

3.4 Interconnectedness of Premorbid Delusional Ideation and Logical Reasoning Skills in High-Risk Individuals

Using the HR group of our sample, a moderation analysis was run with PCET Perseverative Errors moderating the relationship between PCET Accuracy and SOPS Psychotic Symptoms Subscale Item #1 (i.e., the outcome variable). The interaction effect was found to trend towards significance, $b = .06, t(22) = 1.73, p \leq .10, r = .35$, though the predictor variable was not, $b = -.15, t(22) = -.24, p \leq .81, r = .05$. Model analysis showed that the interaction effect did increase the variance explained by the model, and this trended towards significance, $F(1,22) = 2.99, p \leq .10$. However, at low levels of the moderator variable, the strength of the relationship between the predictor variable and the outcome variable was enhanced, $b = -.88, t(22) = -1.35, p \leq .19, r = .28$, while at high levels of the moderator variable, the direction of the relationship between the predictor variable and the outcome variable was reversed, $b = .58, t(22) = .67, p \leq .51, r = .14$ (see Table 4 in Appendix D). This information was used to construct Figure 3, the visual
representation of the moderation relationship seen below, illustrating that an interaction was present.

3. HR group interaction of Perseverative Errors and PCET Accuracy for SOPS Delusional Ideation Rating.

4. DISCUSSION

4.1 Findings and Implications

The aim in this study was to examine the relationship between logical reasoning skills and severity of delusional symptomatology in the continuum of psychotic disorders. The study also aimed to establish evidence of a possible prodromal indicator of post-onset course of illness for delusional symptomatology in psychotic disorders.

We hypothesized that the HR group would show similar deficits as the PD group on logical skills and reasoning inflexibility as measured by the PCET, and that both the HR and PD groups would differ significantly from the LR group on these abilities. This hypothesis was supported by previous research comparing psychotic-disordered and at-risk individuals (Calkins et al., 2009), as well as research examining group differences on the CNB (Irani et al., 2012; Greenwood et al., 2007). While our analysis indicated no
significant group differences among any of the three groups for the selected PCET outcome variables, the medium and small effect sizes observed for the PD and HR groups, respectively, when comparing their mean differences on the PCET measures to the LR group’s indicated that being part of the PD or HR group likely does have an affect on your logical skills and reasoning inflexibility. While some comparisons of the PD and LR groups trended towards significance, most notably on PCET Efficiency, $p \leq .18$, none reached the significant group differences that were hypothesized. This could be due to the small sample size, as previous research into similar hypotheses that established significant group differences typically utilized a much larger sample size (Gur et al., 2007; Irani et al., 2012). In conjunction with the small sample size, the greater percentage of males in the PD group as compared to both the LR and HR groups could have caused a significant effect on our analyses, as the PCET is a visuospatial-based test, which research has shown are processed bilaterally in males and unilaterally in females (Clements et al., 2006); in conjunction with the findings that individuals with schizophrenia show reductions in white matter and problems with inter-hemispheric transfer of information, it is possible that greater deficits would be observed for the group with a greater percentage of males (Whitford et al., 2007; Whitford et al., 2011). This is supported by the larger effect sizes seen in our analyses with just the males for each group. With a larger sample size, this group gender imbalance would likely have not been an issue and, more importantly, we likely would have found stronger evidence in support of our first hypothesis.

We also hypothesized that reasoning inflexibility would moderate the relationship between logical skills and delusional symptomatology, which we tested through a model
using perseverative errors (PER) on the PCET moderating the relationship between accuracy in performance (ACC) on the PCET and SAPS global severity of delusions for individuals in the PD group. This analysis yielded intriguing results, as we found evidence in support of our hypothesized enhancing moderation relationship. Linear regression analysis showed higher levels of ACC predicted lower SAPS Global Rating of Delusions (SAPS-D) scores. Further analysis of this relationship showed that at low levels of PER, the predictive power of ACC for SAPS-D was buffered, while at high levels of PER, it was enhanced. This finding could be interpreted as having greater meaning for lower ACC scores, as lower ACC scores would predict higher SAPS-D scores at higher levels of PER. The higher SAPS-D scores in PD group members with low ACC and high PER provides evidence of the relationship between delusions and belief inflexibility that has been established by previous research (Colbert, Peters, & Garety, 2010; So et al., 2012). While these relationships were unable to be established as significant, our findings warrant further investigation with a larger sample size to see if such significance is present.

Our related third hypothesis sought to examine if the same enhancing moderation relationship was present within the HR group for the prediction of subthreshold delusional ideation as measured by the SOPS Positive Symptoms Subscale Item #1 (SOPS-P1). Analysis showed that the interaction effect trended towards significance, which was the first indication of a possible antagonistic moderator relationship instead of our proposed enhancing one. At low levels of PER, the predictive power of ACC for SOPS-P1 was enhanced, revealing that low levels of PER, higher ACC scores led to even lower scores on SOPS-P1. Most intriguingly, analysis showed that at high levels of PER,
the predictive power of ACC for SOPS-P1 was again enhanced but the direction of the relationship was changed, resulting in a relationship where higher ACC scores actually predicted higher SOPS-P1 scores. This latter finding could be interpreted as meaning that those individuals that had a higher PER yet still achieved higher ACC scores may have initially encountered difficulty with figuring out how to provide the correct response at the very beginning of the test or at the first shift in discernment criteria (e.g., line thickness → shape), but were able to recover and then understand and adapt their reasoning skills to successfully complete the test. We could speculate that because individuals in the HR group have yet to, and perhaps may never, convert to full psychosis, the quality of belief inflexibility observed in those with PD is not yet present in those within the HR group. Examining the mean differences of PER between these two groups showed that while there was not a significant difference, the mean, standard deviation, and range of perseverative errors in the PD group were all greater than those in the HR group and the mean difference across groups when including the LR group showed a medium effect size (see Table 2 in Appendix D). It is possible that our small sample size contributed to this antagonistic moderation effect that has caused us to reject our final hypothesis, but our results do supply a basis for further research to better understand this interaction effect.

Our findings suggest that while deficits in reasoning skills are similar in both PD and HR groups, belief inflexibility differs. Therapeutic interventions targeting delusional ideation within HR individuals are likely to have greater success than similar interventions for PD individuals due to greater level of belief flexibility observed in the
HR group. Should these delusional ideations be targeted earlier in HR individuals, it is possible to slow the progress of delusional ideation into full delusional symptomatology.

4.2 Limitations

While we have provided interesting leads for future research to expand upon our current findings, the limitations inherent in our present study should be addressed in order to know the areas in which improvements could be made. Firstly, the sample we utilized was not balanced by race or sex. Though we have demonstrated that the effects on our results were minimal, controlling for this while gathering a much larger sample will allow us to better demonstrate the validity of our proposed model. Using two different ratings as outcome variables for testing our models for the PD group and the HR group, specifically the SAPS and SOPS, respectively, limits our ability to draw comparisons between the two models. With a single rating system that incorporates the full spectrum of delusional symptom possibilities from asymptomatic to prodrome to acute psychosis, our analysis could produce much stronger conclusions. Future studies should take these factors into consideration to minimize the current study’s limitations.

4.3 Future Research

Possibly one of the more important points that our research has illuminated is the benefit of a move towards developing scales that utilize a spectrum conceptualization of psychotic disorders that incorporates the prodromal and post-onset into a single continuum. While the SOPS has some aspects of this idea present, those PD individuals that score the highest on the SOPS-P1 can have a broad range of scores on the SAPS-D, while almost any score other than the highest on the SOPS-P1 would translate to the very lowest scores on the SAPS-D, if any score at all. Research focus in recent years has
shifted to examining the earlier stages of psychosis in hopes of better understanding its pathogenesis, yet much can still be gained by looking at the lifetime course of illness to see the possible links between the different stages of psychosis. While some studies investigate the ties between the prodromal and post-onset stages of psychosis, no outcome measure for psychotic symptoms has been developed that take this fuller spectrum into account. Our study demonstrated that the PCET yields valuable outcome variables, namely its measures of accuracy and perseverative errors, which can be used to predict the severity of delusional symptomatology. While our two groups yielded different results from a similarly constructed moderation relationship model, a measure of delusional symptomatology that incorporates a broad-spectrum conceptualization from the prodromal stages to post-onset would be an invaluable tool to better assess and understand the lifetime course of psychosis.
List of References


APPENDIX A: SAPS Delusions Subsection

DELUSIONS

Delusions represent an abnormality in content of thought. They are false beliefs that cannot be explained on the basis of the subject's cultural background. Although delusions are sometimes defined as "fixed false beliefs," in their mildest form delusions may persist only for weeks to months, and the subject may question his beliefs or doubt them. The subject's behavior may or may not be influenced by his delusions. The rating of severity of individual delusions and of the global severity of delusional thinking should take into account their persistence, their complexity, the extent to which the subject acts on them, the extent to which the subject doubts them, and the extent to which the beliefs deviate from those that normal people might have. For each positive rating, specific examples should be noted in the margin.

Persecutory Delusions

People suffering from persecutory delusions believe that they are being conspired against or persecuted in some way. Common manifestations include the belief that one is being followed, that one's mail is being opened, that one's room or office is bugged, that the telephone is tapped, or that police, government officials, neighbors, or fellow workers are harassing the subject. Persecutory delusions are sometimes relatively isolated or fragmented, but sometimes the subject has a complex set of delusions involving both a wide range of forms of persecution and a belief that there is a well-designed conspiracy behind them. For example, a subject may believe that his house is bugged and that he is being followed because the government wrongly considers him a secret agent for a foreign government; this delusion may be so complex that it explains almost everything that happens to him. The ratings of severity should be based on duration and complexity.

Have people been bothering you in any way?

Have you felt that people are against you?

Has anyone been trying to harm you in any way?

Has anyone been watching or monitoring you?

Delusions of Jealousy

The subject believes that his/her mate is having an affair with someone. Miscellaneous bits of information are construed as "evidence". The person usually goes to great effort to prove the existence of the affair, searching for hair in the bedclothes, the odor of shaving lotion or smoke on clothing, or receipts or checks indicating a gift has been bought for the lover. Elaborate plans are often made in order to trap the two together.

Have you ever worried that your husband (wife) might be unfaithful to you?

What evidence do you have?

<table>
<thead>
<tr>
<th>Severity</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0</td>
</tr>
<tr>
<td>Questionable</td>
<td>1</td>
</tr>
<tr>
<td>Mild: Delusional beliefs are simple and may be of several different types; subject may question them occasionally</td>
<td>2</td>
</tr>
<tr>
<td>Moderate: Clear, consistent delusion that is firmly held</td>
<td>3</td>
</tr>
<tr>
<td>Marked: Consistent, firmly-held delusion that the subject acts on</td>
<td>4</td>
</tr>
<tr>
<td>Severe: Complex, well-formed delusion that the subject acts on and that preoccupies him a great deal of the time; some aspects of the delusion or his reaction may seem quite bizarre</td>
<td>5</td>
</tr>
</tbody>
</table>
### Delusions of Sin or Guilt

The subject believes that he has committed some terrible sin or done something unforgivable. Sometimes the subject is excessively or inappropriately preoccupied with things he did wrong as a child, such as masturbating. Sometimes the subject feels responsible for causing some disastrous event, such as a fire or accident, with which he in fact has no connection. Sometimes these delusions may have a religious flavor, involving the belief that the sin is unpardonable and that the subject will suffer eternal punishment from God. Sometimes the subject simply believes that he deserves punishment by society. The subject may spend a good deal of time confessing these sins to whomever will listen.

*Have you ever felt that you have done some terrible thing that you deserve to be punished for?*

<table>
<thead>
<tr>
<th>Severity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Questionable</td>
<td>1</td>
</tr>
<tr>
<td>Mild</td>
<td>Delusional beliefs may be simple and may be of several different types; subject may question them occasionally</td>
</tr>
<tr>
<td>Moderate</td>
<td>Clear, consistent delusion that is firmly held</td>
</tr>
<tr>
<td>Marked</td>
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</tr>
<tr>
<td>Severe</td>
<td>Complex, well-formed delusion that the subject acts on and that preoccupies him a great deal of the time; some aspects of the delusion or his reaction may seem quite bizarre</td>
</tr>
</tbody>
</table>

### Grandiose Delusions

The subject believes that he has special powers or abilities. He may think he is actually some famous personage, such as a rock star, Napoleon, or Christ. He may believe he is writing some definitive book, composing a great piece of music, or developing some wonderful new invention. The subject is often suspicious that someone is trying to steal his ideas, and he may become quite irritable if his ideas are doubted.

*Do you have any special or unusual abilities or talents?*

*Do you feel you are going to achieve great things?*

<table>
<thead>
<tr>
<th>Severity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Questionable</td>
<td>1</td>
</tr>
<tr>
<td>Mild</td>
<td>Delusional beliefs may be simple and may be of several different types; subject may question them occasionally</td>
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<tr>
<td>Moderate</td>
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<tr>
<td>Marked</td>
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</tr>
<tr>
<td>Severe</td>
<td>Complex, well-formed delusion that the subject acts on and that preoccupies him a great deal of the time; some aspects of the delusion or his reaction may seem quite bizarre</td>
</tr>
</tbody>
</table>
**Religious Delusions**
The subject is preoccupied with false beliefs of a religious nature. Sometimes these exist within the context of a conventional religious system, such as beliefs about the Second Coming, the Antichrist, or possession by the Devil. At other times, they may involve an entirely new religious system or a pastiche of beliefs from a variety of religions, particularly Eastern religions, such as ideas about reincarnation or Nirvana. Religious delusions may be combined with grandiose delusions (if the subject considers himself a religious leader), delusions of guilt, or delusions of being controlled. Religious delusions must be outside the range considered normal for the subject's cultural and religious background.

Are you a religious person?

Have you had any unusual religious experiences?

What was your religious training as a child?

**Somatic Delusions**
The subject believes that somehow his body is diseased, abnormal, or changed. For example, he may believe that his stomach or brain is rotting, that his hands or penis have become enlarged, or that his facial features are unusual (dysmorphophobia). Sometimes somatic delusions are accompanied by tactile or other hallucinations, and when this occurs, both should be rated. (For example, the subject believes that he has ball bearings rolling around in his head, placed there by a dentist who filled his teeth, and can actually hear them clanking against one another.)

Is there anything wrong with your body?

Have you noticed any change in your appearance?
Ideas and Delusions of Reference
The subject believes that insignificant remarks, statements, or events refer to him or have some special meaning for him. For example, the subject walks into a room, sees people laughing, and suspects that they were just talking about him and laughing at him. Sometimes items read in the paper, heard on the radio, or seen on television are considered to be special messages to the subject. In the case of ideas of reference, the subject is suspicious, but recognizes his idea is erroneous. When the subject actually believes that the statements or events refer to him, then this is considered a delusion of reference.

Have you ever walked into a room and thought people were talking about you or laughing at you?

Have you seen things in magazines or on TV that seem to refer to you or contain a special message for you?

Have people communicated with you in any unusual ways?

Delusions of Being Controlled
The subject has a subjective experience that his feelings or actions are controlled by some outside force. The central requirement for this type of delusion is an actual strong subjective experience of being controlled. It does not include simple beliefs or ideas, such as that the subject is acting as an agent of God or that friends or parents are trying to coerce him to do something. Rather, the subject must describe, for example, that his body has been occupied by some alien force that is making it move in peculiar ways, or that messages are being sent to his brain by radio waves and causing him to experience particular feelings that he recognizes are not his own.

Have you ever felt you were being controlled by some outside force?

Delusions of Mind Reading
The subject believes that people can read his mind or know his thoughts. This is different than thought broadcasting (see below) in that it is a belief without a percept. That is, the subject subjectively experiences and recognizes that others know his thoughts, but he does not think that they can be heard out loud.

Have you ever had the feeling that people could read your mind?
Thought Broadcasting
The subject believes that his thoughts are broadcast so that he or others can hear them. Sometimes the subject experiences his thoughts as a voice outside his head; this is an auditory hallucination as well as a delusion. Sometimes the subject feels his thoughts are being broadcast although he cannot hear them himself. Sometimes he believes that his thoughts are picked up by a microphone and broadcast on the radio or television.

Have you ever heard your own thoughts out loud, as if they were a voice outside your head?

Have you ever felt your thoughts were broadcast so other people could hear them?

Thought Insertion
The subject believes that thoughts that are not his own have been inserted into his mind. For example, the subject may believe that a neighbor is practicing voodoo and planting alien sexual thoughts in his mind. This symptom should not be confused with experiencing unpleasant thoughts that the subject recognizes as his own, such as delusions of persecution or guilt.

Have you ever felt that thoughts were being put into your head by some outside force?

Have you ever experienced thoughts that didn't seem to be your own?
Thought Withdrawal
The subject believes that thoughts have been taken away from his mind. He is able to describe a subjective experience of beginning a thought and then suddenly having it removed by some outside force. This symptom does not include the mere subjective recognition of alogia.

Have you ever felt your thoughts were taken away by some outside force?

Global Rating of Severity of Delusions
The global rating should be based on duration and persistence of delusions, the extent of the subject's preoccupation with the delusions, his degree of conviction, and their effect on his actions. Also consider the extent to which the delusions might be considered bizarre or unusual. Delusions not mentioned above should be included in this rating.

None 0
Questionable 1
Mild: Subject has experienced thought withdrawal, but doubts it occasionally 2
Moderate: Clear experience of thought withdrawal which has occurred on two or three occasions in a week 3
Marked: Clear experience of thought withdrawal which occurs frequently; behavior may be affected 4
Severe: Clear experience of thought withdrawal which occurs frequently, pervades the subject's life and often affects his behavior 5

None 0
Questionable 1
Mild: Delusion definitely present but, at times, the subject questions the belief 2
Moderate: The subject is convinced of the belief, but it may occur infrequently and have little effect on his behavior 3
Marked: The delusion is firmly held; it occurs frequently and affects the subject's behavior 4
Severe: Delusions are complex, well-formed, and pervasive; they are firmly held and have a major effect on the subject's behavior; they may be somewhat bizarre or unusual 5
A. POSITIVE SYMPTOMS

1. Unusual Thought Content/Delusional Ideas

One or more of the following:

a. Perplexity and Delusional mood. Something odd going on. Puzzlement. Confusion about what is real or imaginary. The familiar feels strange, confusing, ominous, threatening, or has special meaning. Sense that self, others, the world has changed. Changes in perception of time. Deja vu.

b. Non persecutory ideas of reference (including unstable delusions of reference).

c. Disturbance of receptive, expressive language. Thought pressure, perseveration, insertion, interference, withdrawal, broadcasting, telepathy.

d. Over valued beliefs. Preoccupation with unusually valued ideas (religion, meditation, philosophy, existential themes). Magical thinking that influences behavior and is inconsistent with subculture norms (e.g., superstitiousness, belief in clairvoyance, "sixth sense", uncommon religious beliefs).

e. Delusional ideas about the body, guilt, nihilism, jealousy, religion, external control, radio and TV messages. Delusions may be present but are not well organized and not tenaciously held.

Severity Scale (circle one)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Never, Absent</td>
</tr>
<tr>
<td>1</td>
<td>Questionably Present: Unexpected thought, feeling, movement, experience. Surprising but easily dismissed.</td>
</tr>
<tr>
<td>2</td>
<td>Mild: Mind “tricks” that are puzzling. Sense that something is different.</td>
</tr>
<tr>
<td>3</td>
<td>Moderate: Unanticipated mental events/beliefs that cannot be dismissed and are also irritating and/or worrisome. A sense that unexpected experiences are somehow meaningful because they won’t go away</td>
</tr>
<tr>
<td>4</td>
<td>Moderately Severe: Notion that experiences are coming from outside the self or that ideas/beliefs are real, but skepticism remains intact.</td>
</tr>
<tr>
<td>5</td>
<td>Severe but not Psychotic: Belief of external control more compelling but doubt can be induced by contrary evidence and others’ opinions. May affect functioning</td>
</tr>
<tr>
<td>6</td>
<td>Severe and Psychotic: Delusional conviction (with no doubt) at least intermittently. Usually interferes with thinking, social relations, or behavior.</td>
</tr>
</tbody>
</table>
### APPENDIX C: Tables

1. Group frequencies of demographics.

<table>
<thead>
<tr>
<th>Participant Characteristics</th>
<th>Psychotic Disorder (n = 17)</th>
<th>High Risk (n = 26)</th>
<th>Low Risk (n = 19)</th>
<th>P Value</th>
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<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Male</td>
<td>10</td>
<td>11</td>
<td>8</td>
<td>.518</td>
</tr>
<tr>
<td>Female</td>
<td>7</td>
<td>15</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Age (yr)</td>
<td></td>
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<td></td>
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<tr>
<td>11-17</td>
<td>2</td>
<td>6</td>
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<td>.237</td>
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<td>18-25</td>
<td>15</td>
<td>20</td>
<td>18</td>
<td></td>
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<tr>
<td>Race</td>
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<td>Caucasian</td>
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<td>African American</td>
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<tr>
<td>Education Level</td>
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<tr>
<td>Did not complete high school</td>
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<td>9</td>
<td>0</td>
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<tr>
<td>High School</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Some college</td>
<td>7</td>
<td>7</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>College</td>
<td>1</td>
<td>6</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Masters</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td></td>
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<tr>
<td>Doctorate</td>
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<td>0</td>
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<tr>
<td>Maternal Education Level</td>
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<td></td>
<td>.273</td>
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<tr>
<td>Did not complete high school</td>
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<tr>
<td>High school</td>
<td>1</td>
<td>8</td>
<td>5</td>
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<tr>
<td>Some college</td>
<td>1</td>
<td>7</td>
<td>1</td>
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<tr>
<td>College</td>
<td>6</td>
<td>3</td>
<td>6</td>
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<tr>
<td>Masters</td>
<td>4</td>
<td>5</td>
<td>7</td>
<td></td>
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<tr>
<td>Doctorate</td>
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<td>2</td>
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<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>2</td>
<td>1</td>
<td>0</td>
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</tbody>
</table>

*Post-hoc analysis showed a significant difference (p<.05) between HR and LR groups, though this was expected given age differences.
2. Group means comparison of PCET scores.

<table>
<thead>
<tr>
<th></th>
<th>PCET Scores</th>
<th>Psychotic Disorder (n = 17 / male n = 10)</th>
<th>High Risk (n = 26 / male n = 11)</th>
<th>Low Risk (n = 19 / male n = 8)</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Accuracy</td>
<td>All Participants</td>
<td>1.56</td>
<td>.71</td>
<td>1.72</td>
<td>.65</td>
</tr>
<tr>
<td></td>
<td>Males Only</td>
<td>1.57</td>
<td>.48</td>
<td>1.73</td>
<td>.48</td>
</tr>
<tr>
<td>Perseverative Errors</td>
<td>All Participants</td>
<td>20.47</td>
<td>13.64</td>
<td>16.15</td>
<td>11.54</td>
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<tr>
<td></td>
<td>Males Only</td>
<td>19.40</td>
<td>6.38</td>
<td>16.73</td>
<td>11.11</td>
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<tr>
<td>Efficiency</td>
<td>All Participants</td>
<td>.20</td>
<td>.09</td>
<td>.23</td>
<td>.09</td>
</tr>
<tr>
<td></td>
<td>Males Only</td>
<td>.20</td>
<td>.07</td>
<td>.23</td>
<td>.07</td>
</tr>
<tr>
<td>Total Correct Responses</td>
<td>All Participants</td>
<td>42.41</td>
<td>10.39</td>
<td>30.44</td>
<td>3.52</td>
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<tr>
<td></td>
<td>Males Only</td>
<td>43.60</td>
<td>9.66</td>
<td>30.64</td>
<td>5.41</td>
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<tr>
<td>Total Errorneus Responses</td>
<td>All Participants</td>
<td>34.06</td>
<td>19.14</td>
<td>26.10</td>
<td>16.10</td>
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<tr>
<td></td>
<td>Males Only</td>
<td>33.80</td>
<td>11.02</td>
<td>27.82</td>
<td>12.77</td>
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</tbody>
</table>

*Standardized mean difference (d) of between group variance across all groups.
^Standardized mean difference (d) for PD and HR.
^Standardized mean difference (d) for HR and LR.
3. PD group moderation analysis summary.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Centered Moderator</th>
<th>Low Moderator</th>
<th>High Moderator</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>SE</td>
<td>β</td>
</tr>
<tr>
<td>Model 1: simple effects&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0</td>
<td>.35</td>
<td>-.21</td>
</tr>
<tr>
<td>PCET Accuracy</td>
<td>-42</td>
<td>1.02</td>
<td>-.21</td>
</tr>
<tr>
<td>PCET Perseverative Errors</td>
<td>-.02</td>
<td>.05</td>
<td>-.17</td>
</tr>
</tbody>
</table>

Model 2: main and interaction effects<sup>b</sup>

| Constant                      | -.31   | .47| .87    | -.55   | .87| .87    | -.118  | 1.25| .87    |
| PCET Accuracy                 | -1.13  | 1.25| -.56  | -.59  | 1.03| -.30   | -1.68  | 1.63| -.87   |
| PCET Perseverative Errors     | -.02   | .07| -.63  | -.06  | .07| -.63   | -.06   | .07| -.63   |
| PCET Accuracy × PCET          | -.04   | .04| -.36  | -.04  | .04| -.47   | -.04   | .04| -.43   |
| Perseverative errors          |        |    |        |        |    |        |        |    |        |
| $R^2$ change                  | .08    |    |        |        |    |        |        |    |        |

<sup>a</sup>n=17 (PD), centered outcome variable is SAPS Global Severity of Delusions rating (SAPS Item 720)
4. HR group moderation analysis summary.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Centered Moderator B</th>
<th>Centered Moderator SE</th>
<th>Centered Moderator β</th>
<th>Low Moderator B</th>
<th>Low Moderator SE</th>
<th>Low Moderator β</th>
<th>High Moderator B</th>
<th>High Moderator SE</th>
<th>High Moderator β</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0</td>
<td>.20</td>
<td>.17</td>
<td>.46</td>
<td>.46</td>
<td>-.17</td>
<td>-.46</td>
<td>.31</td>
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</tr>
<tr>
<td>PCET Accuracy</td>
<td>-.47</td>
<td>.64</td>
<td>-.31</td>
<td>-.47</td>
<td>.64</td>
<td>-.31</td>
<td>-.47</td>
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<tr>
<td>PCET Perseverative Errors</td>
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<td>-.17</td>
<td>-.02</td>
<td>.04</td>
<td>-.17</td>
<td>-.02</td>
<td>.04</td>
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</table>

Model 2: main and interaction effects

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE</th>
<th>β</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>.40</td>
<td>.30</td>
<td>.17</td>
</tr>
<tr>
<td>PCET Accuracy</td>
<td>-.15</td>
<td>.64</td>
<td>-.10</td>
</tr>
<tr>
<td>PCET Perseverative Errors</td>
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<td>.14</td>
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<tr>
<td>PCET Accuracy × PCET</td>
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<td>.04</td>
<td>.37</td>
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</tbody>
</table>

Perseverative errors

\[ R^2 = .15 \]

\[ R^2 \text{ change} = .12 \]

*a* = 26 (HR), centered outcome variable is SOPS Positive Symptoms subscale Unusual Thought Content/Delusional Ideas rating (SOPS item #1)

\[ p = .098 \]