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## Neurocognitive predictors of metacognition in individuals at clinical high risk for psychosis

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### Abstract

**Background**—Metacognition refers to the ability to evaluate and control our cognitive processes. While studies have investigated metacognition in schizophrenia and clinical high risk for psychosis (CHR), less is known about the potential mechanisms which result in metacognitive deficits.

**Aims**—We aimed to investigate whether neurocognitive functions including attention, working memory, verbal learning and executive functions predicted the tendency to focus on one’s thoughts (cognitive self-consciousness) and beliefs in the efficacy of one’s cognitive skills (cognitive confidence).

**Method**—Participants (130 CHR individuals) were recruited as part of the multi-site PREDICT study. They were assessed using the Metacognitions Questionnaire (MCQ) as well as measures of executive function (WCST), attention (N-Back), working memory (LNS) and verbal learning (AVLT).

**Results**—Cognitive competence was negatively correlated with N-Back while cognitive self-consciousness was positively correlated with N-Back and LNS. Linear regression analysis with N-Back, AVLT, LNS and WCST as predictors showed that neurocognition significantly predicted cognitive self-consciousness, with N-Back, LNS and WCST as significant predictors. The model accounted for 14% of the variance in cognitive self-consciousness. However, neurocognition did not result in a significant predictive model of cognitive competence.

**Conclusions**—Neurocognition was associated with an increased focus on one’s thoughts, but it was not associated with higher confidence in one’s cognitive skills. Neurocognition accounted for less than one-sixth of the variance in metacognition, suggesting that interventions that target neurocognition are unlikely to improve metacognitive abilities.

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## Keywords

clinical high risk; metacognition; neurocognition

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## Introduction

Metacognition refers to the ability to evaluate and control our cognitive processes. Metacognition allows us to evaluate the state of our cognitive functions (*metacognitive monitoring*), direct cognitive and behavioural performance (*metacognitive control*), and understand task difficulty and resource requirements (*metacognitive knowledge*) (Flavell, 1979). There is growing evidence that understanding the role of metacognitive functions in schizophrenia may provide solutions to long-standing problems of cognitive remediation, including lack of far transfer and poor gains in real world functioning. Although metacognitive deficits can exist even in the absence of neurocognitive dysfunction, there is often a close relation between metacognition and neurocognitive abilities. Evidence shows that metacognition is partly associated with neurocognitive functions like attention, learning ability, working memory and executive functions.

While metacognition has been extensively studied in schizophrenia, few studies have investigated metacognition in individuals at clinical high risk for psychosis (CHR). Previous studies have highlighted three aspects of metacognition in CHR. Firstly, CHR individuals perform worse than healthy controls on metacognition tasks while individuals with psychosis perform worse than CHR (Morrison et al., 2007). Secondly, in CHR as well as healthy individuals metacognitive deficits are associated with psychosis proneness and paranoid beliefs, providing support for the view that maladaptive metacognitions may contribute to the development of unusual perceptual experiences. Finally, metacognition in CHR individuals is associated with altered cortical thickness in brain regions that consistently show reductions in schizophrenia, including the inferior and middle frontal gyri, superior temporal cortex and insula.

In a previous analysis using the same data (Barbato et al., 2014), it was reported that CHR individuals performed more poorly than help-seeking controls on a self-reported measure of metacognition, the Metacognitions Questionnaire (MCQ; Cartwright-Hatton and Wells, 1997). Furthermore, CHR individuals who later transitioned to psychosis performed significantly worse on the MCQ when compared with those who did not make the transition. MCQ includes three subscales pertaining to positive and negative beliefs about thoughts and two subscales pertaining to cognition – cognitive self-consciousness and cognitive confidence. Cognitive self-consciousness refers to the tendency to focus on one's thought processes, while cognitive confidence refers to belief in the efficacy of one's cognitive skills. From a neurocognitive perspective, cognitive self-consciousness and cognitive confidence are most likely to be influenced by neurocognitive functions.

In this paper, we sought to investigate whether neurocognition predicts cognitive self-consciousness and cognitive confidence in CHR individuals. We chose neurocognitive functions that are associated with metacognition, including attention, verbal learning, working memory and executive functions. We hypothesized that neurocognition will

significantly predict cognitive self-consciousness and cognitive confidence in CHR individuals.

## Method

### Participants

The sample consisted of 130 individuals at CHR for psychosis recruited as part of a multi-site NIMH funded study, Enhancing the Prospective Prediction of Psychosis (PREDICT) conducted at the University of Toronto, University of North Carolina and Yale University (see Barbato et al., 2014). Briefly, CHR status was determined using the Structured Interview for Psychosis-Risk Syndromes (SIPS) and Scale of Prodromal Symptoms (SOPS) (McGlashan et al., 2010). One hundred and twenty-eight participants met criteria for attenuated positive symptom syndrome, which involves the emergence or worsening of non-psychotic level disturbance in thought content, thought process or perceptual abnormality over the past year. Two participants met criteria for genetic risk and deterioration, which requires either a first degree relative with a psychotic disorder or the participant having schizotypal personality disorder as well as a drop of 30% in functioning on the Global Assessment of Functioning scale in the past year.

Participants were excluded if they ever met criteria for a psychotic disorder, had  $IQ < 70$ , a history of neurological conditions, or used anti-psychotics. Furthermore, anti-psychotics were not used at any point in this study. All data for the current analysis were collected in a single session.

The study protocols and informed consents were reviewed and approved by the ethical review boards of all three study sites.

### Measures

CHR status was determined using the SIPS and SOPS (McGlashan et al., 2010).

The cognitive subscales of the Metacognitions Questionnaire (MCQ) (Cartwright-Hatton and Wells, 1997) includes seven items on cognitive self-consciousness, and 10 items on cognitive confidence, rated on a 4-point Likert scale. The cognitive self-consciousness subscale assesses the tendency to focus on one's thought processes and includes items like *I think a lot about my thoughts*, while the cognitive confidence subscale assesses beliefs in the efficacy of one's cognitive skills and includes items like *I have difficulty knowing if I have actually done something or just imagined it*.

The Wisconsin Card Sorting Test (WCST) was used to assess executive functioning. The participant has to use feedback and match cards based on a rule that changes frequently. Perseverative errors occur when the participant continues to sort the cards according to an erroneous rule (despite negative feedback) and reflects the ability for concept formation, profiting from correction and conceptual flexibility.

The Auditory Verbal Learning Test (AVLT) requires participants to repeat a list of 15 words after hearing them, across five trials. The total number of words reproduced was used to represent the participant's learning ability.

In the 1-back version of the N-Back test, participants have to respond if the stimulus presented is the same as the item presented immediately before it. Total correct score was used as a measure of sustained attention.

In Letter-Number Sequencing (LNS), the participant is presented with increasingly long combinations of letters and numbers and they have to mentally organize and reproduce them with the numbers first (in ascending order) and then the letters (in alphabetical order). LNS requires holding on to and manipulation of information mentally, and was used as a measure of working memory.

### Statistical analysis

Missing data were imputed in IBM Amos using regression imputation with FIML estimation. Two linear regression analyses were performed. WCST, AVLT, N-Back and LNS were used as predictors to determine whether neurocognitive functions predicted cognitive self-consciousness in analysis 1 and cognitive confidence in analysis 2. Bonferroni correction for multiple comparison was applied and results were only considered significant if they were significant at  $p = 0.025$ .

### Results

The participants in this sample ( $n = 130$ ) had a mean age of 20.68 years ( $SD = 3.91$ ) and the majority were male (58.5%), white (80.6%), and single (93.1%). Of these participants, 56.1% had been to college or received graduate degrees or certificates, while 33% did not complete high school.

Correlational analyses shows that cognitive competence has a significant negative correlation with N-Back [ $r(128) = -0.27, p = 0.002$ ] and cognitive self-consciousness has significant positive correlations with N-Back [ $r(128) = 0.25, p = 0.004$ ] and LNS [ $r(128) = -0.25, p = 0.004$ ].

Linear regression analysis with N-Back, AVLT, LNS and WCST as predictors showed that neurocognition significantly predicted cognitive self-consciousness [ $F(4,125) = 4.99, p = 0.001$ ]. The significant predictors in the model were N-Back, LNS and WCST (see Table 1). The model accounted for 14% of the variance in cognitive self-consciousness ( $R^2 = 0.14$ ). Linear regression analysis with N-Back, AVLT, LNS and WCST as predictors showed that neurocognition did not predict cognitive competence (after Bonferroni correction) [ $F(4,125) = 2.41, p = 0.053; R^2 = 0.072$ ].

### Discussion

Results showed that neurocognitive functions significantly predicted cognitive self-consciousness but not cognitive confidence in CHR. The most significant individual predictor of cognitive self-consciousness was executive function, followed by working

memory and attention. However, the final model accounted for less than 15% of the variance in cognitive self-consciousness.

### **Metacognitive monitoring in CHR**

The cognitive self-consciousness subscale of MCQ consists of items that assess the participant's need to control their thoughts and negative consequences of not doing so (Wells and Cartwright Hatton, 2004). The items enquire about preoccupation with one's thoughts and thought processes, uncertainty about thoughts, and tendency to monitor and evaluate one's thoughts. In other words, it taps into what has been referred to elsewhere as metacognitive monitoring (Flavell, 1979). We found that higher levels of attention, working memory and executive functioning were associated with higher levels of metacognitive monitoring in CHR.

The cognitive confidence subscale of MCQ consists of items that assess the participant's confidence in memory and attention (Wells and Cartwright-Hatton, 2004). The items enquire about their confidence in memory for actions, words, names and places, how much they trust their memory, and difficulties with attention and distractibility. While both subscales pertain to metacognitive monitoring, cognitive confidence differs in that the items refer to specific problems with attention, concentration and memory rather than general preoccupation with thoughts and thought processes. We did not find higher levels of neurocognition (especially attention and memory) to be associated with greater cognitive confidence, as might be expected in a healthy population.

Taken together, these results suggest that in CHR individuals higher neurocognitive functioning is associated with an increased tendency to focus on thought processes, but it does not result in higher confidence in their thought processes. Adequate metacognitive monitoring is a prerequisite for good metacognitive control and metacognitive knowledge. To borrow an example from education, students with poor metacognitive monitoring are less likely to avoid distractions and more likely to spend time learning materials they already know instead of focusing on what they do not know.

### **Role of neurocognitive functions**

Furthermore, results showed that attention, working memory and executive functions predicted cognitive self-consciousness. Attention is a prerequisite for all upstream neurocognitive processes and is therefore expected to contribute to metacognitive functioning. Poor working memory is associated with decreased metacognitive ability to distinguish one's thoughts in schizophrenia. Finally, specific aspects of executive function have been associated with specific domains of metacognition in schizophrenia. Our findings suggest that, among CHR, better neurocognition is associated with increased focus on thought processes. However, given that a substantial part of metacognition is not accounted for by neurocognition, neurocognition does not predict cognitive confidence, and that this sample of CHR individuals performed worse than non-patients (but better than psychosis patients) on metacognition (see Barbato et al., 2014), our findings provide support for the view that metacognitive deficits in the CHR are not primarily the result of deficits in individual neurocognitive processes.

## Limitations

The primary limitation of this study is the use of a self-report measure and the absence of an objective measure of metacognition. While the phenomena of interest in this analysis (cognitive self-consciousness and cognitive confidence) can only be reported subjectively, this study could have benefitted from the added inclusion of an objective measure of metacognition, allowing for greater specificity and confidence in the findings.

## Conclusions

Metacognitive deficits in schizophrenia are associated with symptom severity, and poor treatment outcomes including poor social functioning, community functioning and decreased insight. Metacognition also possibly moderates the relation between cognition and functional impairments in schizophrenia. Our findings show that neurocognition contributes to less than one-sixth of variance in metacognition and therefore suggests that changes in neurocognition are unlikely to substantially improve metacognition.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

## Acknowledgments

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**Table 1.**

Neurocognitive predictors of cognitive self-consciousness in clinical high-risk individuals

	Unstandardized coefficients		Standardized coefficients
	<i>B</i>	<i>SE</i>	$\beta$
Intercept	6.19	3.048	
N-Back	0.060*	0.029	0.20
1			
AVLT	0.040	0.051	0.078
LNS	0.31*	0.15	0.24
WCST	0.32*	0.12	0.25

AVLT, auditory verbal learning task; LNS, letter number sequencing task; WCST, Wisconsin card sorting task.

\*  $p < 0.05$ .