Conceptual Disorganization Weakens Links in Cognitive Pathways: Disentangling Neurocognition, Social Cognition, and Metacognition in Schizophrenia

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ABSTRACT

Disentangling links between neurocognition, social cognition, and metacognition offers the potential to improve interventions for these cognitive processes. Disorganized symptoms have shown promise for explaining the limiting relationship that neurocognition holds with both social cognition and metacognition. In this study, primary aims included: 1) testing whether conceptual disorganization, a specific disorganized symptom, moderated relationships between cognitive processes, and 2) examining the level of conceptual disorganization necessary for links between cognitive processes to break down. To accomplish these aims, comprehensive assessments of conceptual disorganization, neurocognition, social cognition, and metacognition were administered to 67 people with schizophrenia-spectrum disorders. We found that conceptual disorganization significantly moderated the relationship between neurocognition and metacognition, with links between cognitive processes weakening when conceptual disorganization is present even at minimal levels of severity. There was no evidence that conceptual disorganization—or any other specific disorganized symptom—drove the limiting relationship of neurocognition on social cognition. Based on our findings, conceptual disorganization appears to be a critical piece of the puzzle when disentangling the relationship between neurocognition and metacognition. Roles of specific disorganized symptoms in the neurocognition – social cognition relationship were less clear. Findings from this study suggest that disorganized symptoms are an important treatment consideration when aiming to improve cognitive impairments.

Keywords: Conceptual disorganization; Neurocognition; Social cognition; Metacognition; Schizophrenia

1. Introduction

Repeating a seven-digit phone number, recognizing fear instead of surprise on a person's face, and thinking about how you fit into a social group are all processes that go awry in schizophrenia; determining how these processes are connected is a critical step to understanding them. Cognitive impairments, such as those described in the previous sentence, are cardinal symptoms of schizophrenia (Frith, 1992; Green, 1996; Green et al., 2008; Lysaker et al., 2005; Penn et al., 1997). Neurocognition, social cognition, and metacognition represent separate—but related—types of cognitive impairments (Allen et al., 2007; Fanning et al, 2012; Lysaker et al., 2013; Pinkham et al., 2003). Of these, neurocognitive impairments are the most often cited in literature and involve reductions in abilities ranging from processing speed to executive functioning (Green, 1996; Green et al., 2004; Saykin et al., 1991). Social cognitive impairments consist of deficiencies in the processes (e.g., theory of mind, emotion recognition, emotion processing) required for consolidating social situational factors and perceptions to draw inferences about other people (Green et al., 2008). Metacognitive impairments reflect problems with a spectrum of mental activities, ranging from discrete (e.g., recognizing specific thoughts and feelings) to synthetic acts (e.g., integrating an array of intentions, thoughts, feelings, and connections between events into a complex representation of oneself and others; Dimaggio and Lysaker, 2015; Lysaker et al., 2013).

Disentangling the links between neurocognition, social cognition, and metacognition offers the potential to map connections within cognitive pathways and, in turn, design interventions to more effectively target cognitive impairments. It has been suggested that adequate neurocognition is a necessary, but not sufficient, requirement for exhibiting more complex abilities such as social cognition and metacognition (Fanning et al., 2012; Penn et al.,

1997; Lysaker et al., 2010). If this is the case, a person with schizophrenia who demonstrates effective neurocognition calls on these abilities when they connect social situational factors and perceptions (or discrete and synthetic acts for metacognition) to draw inferences, whereas those with poor neurocognition are unable to make these connections. Thus, neurocognitive functioning appears to be an essential first stage and a limiting factor in social cognitive and metacognitive performance. Importantly, the limiting relationship of neurocognition on social cognition and metacognition is likely influenced by additional factors. Examining potential moderators would allow us to understand the likelihood that neurocognitive abilities could be effectively harnessed for social cognition and metacognition by illustrating when links between cognitive processes are strongest—and weakest.

Disorganized symptoms have exhibited promise as a moderator for the limiting relationship that neurocognition holds with both social cognition and metacognition. They are more strongly related to cognitive processes than reality distortion or negative symptoms (Hamm et al., 2012; Ventura et al., 2010; Ventura et al., 2013) and are inversely associated with long-term functioning (Evans et al., 2004; Shenton et al., 1992; Smith et al., 2002). A recent study from our group demonstrated that disorganized symptoms are an integral link in cognitive pathways, with connections between cognitive processes weakening as disorganized symptoms increase (Minor and Lysaker, 2014). This finding suggests that when disorganized symptoms are present, people with schizophrenia are no longer able to effectively utilize the neurocognitive abilities necessary for performing social cognitive or metacognitive tasks. It is also in line with classic and contemporary models of disorganization in schizophrenia (Bleuler, 1911; Hardy-Bayle et al., 2003). In particular, it harkens back to Bleuler's belief that disruptions in cognitive processes lead to difficulties forming complex thoughts and engaging in goal-directed behaviors

(Bleuler, 1911). According to Bleuler, a "loosening of associations"—similar to current conceptualizations of disorganized symptoms—is at the core of these cognitive disruptions.

Although findings from Minor and Lysaker (2014) support previous models, no one has yet examined how specific types of disorganized symptoms affect the limiting relationship of neurocognition on social cognition and metacognition. Conceptual disorganization is a disorganized symptom that is assessed using descriptors (e.g., loose associations, disrupted goal-directed sequencing, illogicality) that are similar to Bleuler's "loosening of associations" paradigm; thus, it is likely to play a prominent role. If conceptual disorganization is found to moderate relationships between cognitive processes, it is also essential to determine the level of severity where links between neurocognition, social cognition, and metacognition weaken. Identifying specific moderators and showing the level of severity necessary for neurocognition to no longer exert influence on social cognition and metacognition have important potential clinical ramifications. Accomplishing these goals could lead to more refined treatment targets (i.e., conceptual disorganization) in an effort to improve cognitive impairments.

1.1 Aims of the Study

This study had two primary aims. First, we examined whether conceptual disorganization moderated the effects of neurocognition on social cognition and metacognition. Second, we determined the level of conceptual disorganization severity necessary for neurocognition to no longer exert significant influence on social cognition and metacognition.

2. Materials and Methods

2.1 Participants

Participants consisted of 67 outpatients with DSM-IV-TR (American Psychological Association, APA, 2000) diagnoses of schizophrenia (n = 45) or schizoaffective disorder (n = 22). Diagnoses were confirmed using the Structured Clinical Interview for DSM-IV-TR Disorders-Patient Edition (SCID-I/P; First et al., 2002). All participants were recruited from a Midwestern VA Medical Center and were part of the sample reported in a previous paper (Minor and Lysaker, 2014). Exclusion criteria consisted of: a) any change in medication, housing, or outpatient status (e.g., hospitalizations) within the past 30 days; b) active substance dependence; and c) a documented intellectual disability at any time point (based on medical record review). This study was part of a larger randomized controlled trial that focused on the effects of cognitive remediation in Serious Mental Illness. For this study, only baseline scores were examined (i.e., prior to intervention). All procedures were approved by local Institutional Review Boards. Demographic and clinical data for participants are reported in Table 1.

[INSERT TABLE ONE HERE]

2.2 Measures

2.2.1 Conceptual disorganization.

Conceptual disorganization is an item on the Positive and Negative Syndrome Scale (PANSS; Kay et al., 1987) that reflects loose associations, disrupted goal-directed sequencing, and circumstantiality. Conceptual disorganization is 1 of 7 specific disorganized symptoms measured on the PANSS; other disorganized symptoms include: 1) difficulty in abstract thinking; 2) stereotyped thinking; 3) lack of insight; 4) poor attention; 5) tension; and 6) mannerisms/ posturing (Bell et al., 1994). The PANSS is a 30-item scale, with each item ranging from 1

("absent") to 7 ("extreme"). The overall scale has exhibited strong internal consistency (Kay et al., 1987), predictive validity (Bell et al., 1992), and interrater reliability (Bell et al., 1992; Lysaker et al., 2013). For this study, all research staff were trained on the PANSS and demonstrated good interrater reliability ($\alpha \geq 0.80$).

2.2.2 Neurocognition.

The Measurement and Treatment Research to Improve Cognition in Schizophrenia (MATRICS; Nuechterlein et al., 2008) was designed specifically to measure neurocognitive functioning in schizophrenia and has been widely used in populations across the schizophrenia-spectrum (De Herdt et al., 2013; McLeery et al., In Press; Minor et al., 2015a). It assesses 7 neurocognitive domains (processing speed, attention, working memory, verbal learning, visual learning, reasoning and problem solving, and social cognition). In this study, we calculated a neurocognitive composite score that included all MATRICS subtests with one exception: the Mayer-Salovey-Caruso Emotional Intelligence Test (MSCEIT; Mayer et al., 2002) was included with social cognition instead of neurocognition measures. The neurocognition composite was created by excluding the MSCEIT and providing equal weight to the remaining six domains.

2.2.3 Social cognition.

Four separate measures were used to assess social cognition. These measures assessed social cognition across three domains: emotional processing, emotion recognition, and theory of mind. A social cognition composite score was calculated by providing equal weight to these three domains. The MSCEIT was the measure of emotional processing used in this study and it was administered as part of the MATRICS battery. This version consisted of 29 items from the

perceiving emotions and managing emotions subscales. The MSCEIT has exhibited strong psychometric properties in previous studies using schizophrenia samples (Eack et al., 2010; Kee et al., 2009; Nuechterlein et al., 2008).

Emotion recognition was measured using the Bell-Lysaker Emotion Recognition Task (BLERT; Bell et al., 1997). The BLERT contains 21 video segments and asks subjects to identify which emotion is being portrayed in each segment. The BLERT is considered a gold standard measure of emotion recognition; it has been widely used in schizophrenia and was selected by the Social Cognition Psychometric Evaluation (SCOPE) study as among the best existing emotion recognition measures (Pinkham et al., 2014). It has demonstrated categorical stability over time, as well as discriminant validity in community, substance abuse, and schizophrenia samples (Bell et al., 1997).

Theory of mind was assessed using two measures. The English language version of the Hinting Task (Corcoran and Frith, 2005; Greig et al., 2004) asks subjects to judge the intentions of a fictional character based on hints embedded within a story across 10 different scenarios. For each scenario, a score of "2' is given if the subject correctly answers the question on the first attempt. A "1" is achieved if a correct response is made after an explicit hint and a "0" is given if the subject is incorrect on both attempts. The Social Attributions Test- Multiple Choice (SAT-MC; Bell et al., 2010) is a non-verbal theory of mind measure. Participants are presented with an abstract animation lasting one minute. The animation features social situations involving a large triangle, small triangle, and small circle (see Klin, 2000; Klin and Jones, 2006). After viewing the animation twice, subjects were asked 19 multiple choice questions concerning interactions in the animation. Both the Hinting Task and the SAT-MC have shown strong psychometric properties in schizophrenia studies (Bell et al., 2010; Pinkham et al., 2014).

2.2.4 Metacognition.

The Metacognition Assessment Scale-Adapted (MAS-A; Lysaker et al., 2005, adapted from Semerari et al., 2003) measures one's ability to consider implicit and explicit information to think about themselves and others; it was used to measure metacognition in this study. It consists of 28 items. Total score ranges from 0-28, with higher scores indicating greater metacognition (Lysaker et al., 2013). Ratings were conducted by trained clinicians who had demonstrated good inter-rater reliability ($\alpha \geq 0.80$). The MAS-A has exhibited good reliability and validity in schizophrenia samples (Lysaker et al., 2010; Lysaker et al., 2012).

Content for MAS-A ratings was generated using the Indiana Psychiatric Illness Interview (IPII; Lysaker et al., 2002). IPII interviews were conducted by trained clinicians and averaged 30-60 minutes. The IPII differs from many psychiatric interviews in that little content is introduced by the clinician. It is designed to elicit open-ended responses from subjects about how they view their life and how mental illness fits into narratives about their life.

2.3 Statistical analyses

Analyses were conducted in two steps. First, correlations between conceptual disorganization and cognitive processes were investigated, with the expectation that conceptual disorganization would be associated with neurocognition, social cognition, and metacognition. Second, moderation was tested using linear regression. Regressions were analyzed to determine when links between cognitive processes (i.e., neurocognition – social cognition, neurocognition – metacognition) were affected by conceptual disorganization. If conceptual disorganization did not show evidence of moderation, post hoc analyses were conducted to test if other specific

disorganized symptoms served as moderators. Potential moderators were examined using PROCESS for SPSS (Hayes, 2012). Symptoms, neurocognition, and the cross-product of these two variables were entered simultaneously as predictors in all regression analyses and social cognition or metacognition were entered as the outcome variable. The Johnson-Neyman technique (Hayes, 2013; Rast et al., 2014) was employed to identify the level of disorganized symptom severity where links between cognitive processes were no longer significant. If moderation was found, additional post-hoc analyses were conducted to further illustrate the role of conceptual disorganization in cognitive pathways. In these analyses, correlations between cognitive processes were run after splitting participants into low and moderate conceptual disorganization groups.

3. Results

3.1 Associations between conceptual disorganization and cognitive processes.

A correlation matrix was created to test our expectation that conceptual disorganization would be significantly related to neurocognition, social cognition, and metacognition. We observed that conceptual disorganization was significantly associated with social cognition, $r(67) = -0.34$, $p < 0.01$. Relationships between conceptual disorganization and neurocognition, $r(67) = -0.09$, $p = 0.45$, and metacognition, $r(67) = -0.10$, $p = 0.41$, did not reach the level of significance. Our hypothesis that conceptual disorganization would be associated with cognitive processes was only partially supported.

3.2 Conceptual disorganization as a moderator for the relationship between neurocognition and social cognition.

Moderation analyses are presented in Table 2. A linear regression was conducted to test the hypothesis that conceptual disorganization moderated the relationship between neurocognition and social cognition. After controlling for independent effects of conceptual disorganization and neurocognition, the cross product of these variables did not account for a significant decrease in social cognition. Thus, our hypothesis that conceptual disorganization drove the moderating effect of disorganized symptoms was not supported.

Post-hoc analyses examined whether other specific disorganized symptoms accounted for the moderating effect of disorganized symptoms in the neurocognition – social cognition relationship. No cross product was significant once independent effects were controlled for: 1) difficulties in abstract thinking, $\beta = -0.26$, $t(63) = -0.75$, $p = 0.45$; 2) stereotyped thinking, $\beta = 0.04$, $t(63) = 0.16$, $p = 0.88$; 3) lack of insight, $\beta = -0.64$, $t(63) = -1.80$, $p = 0.08$, $p = 0.13$; 4) poor attention, $\beta = 0.16$, $t(63) = 0.60$, $p = 0.55$; 5) tension, $\beta = -0.01$, $t(63) = -0.02$, $p = 0.98$; and 6) mannerisms/ posturing, $\beta = -0.30$, $t(63) = -0.73$, $p = 0.47$. This suggests that no single disorganized symptom drove the moderating effect in the neurocognition – social cognition relationship.

[INSERT TABLE 2 HERE]

3.3 Conceptual disorganization as a moderator for the relationship between neurocognition and metacognition.

To test our hypothesis that conceptual disorganization moderated the relationship between neurocognition and metacognition, a second linear regression was conducted. After controlling for independent effects of conceptual disorganization and neurocognition, the cross

product of these variables accounted for a significant decrease in metacognition (Table 2). When this moderating effect was further examined using the Johnson-Neyman technique, we observed that links between neurocognition and metacognition were no longer significant once individuals exhibited minimal to mild levels of conceptual disorganization (M = 2.20; SE = 0.12). Figure 1 illustrates the conditional effect for the limiting relationship of neurocognition on metacognition at different levels of conceptual disorganization. These findings support our hypothesis that conceptual disorganization drives the moderating effect of disorganized symptoms on the neurocognition – metacognition relationship. They also suggest that links between these cognitive processes break down at minimal to mild levels of conceptual disorganization.

[INSERT FIGURE 1 HERE]

Our hypothesis was supported even though conceptual disorganization was not significantly correlated to neurocognition or metacognition in the overall sample. To investigate this finding, post-hoc correlations were conducted between conceptual disorganization, neurocognition, and metacognition in people displaying low (score < 3; mean = 1.25; SD = 0.44; n = 47) and moderate (score ≥ 3; mean = 3.70; SD = 0.80; n = 20) conceptual disorganization scores. Based on the moderation effects described above, we expected that neurocognition (Low: mean = 24.30; SD = 10.43; Moderate: mean = 23.00; SD = 10.13) and metacognition (Low: mean = 11.59; SD = 4.05; Moderate: mean = 10.78; SD = 3.54) would only be related at low levels of conceptual disorganization. We observed that neurocognition and metacognition were significantly associated in the low, $r(47) = 0.38$, $p = 0.01$, but not moderate conceptual disorganization group, $r(20) = 0.07$, $p = 0.20$. This provided support for our post-hoc hypothesis.

4. Discussion

The purpose of this study was to determine whether conceptual disorganization could disentangle relationships between neurocognition, social cognition, and metacognition. Two primary findings emerged. First, conceptual disorganization significantly moderated the relationship between neurocognition and metacognition, with links between these cognitive processes weakening as conceptual disorganization increased. Further, we observed that neurocognition no longer exerted significant influence on metacognition at minimal to mild levels of conceptual disorganization. Second, conceptual disorganization—or any other single disorganized symptom—did not appear to moderate relationships between neurocognition and social cognition. Both findings hold important implications for clinicians and researchers.

The finding that conceptual disorganization moderated the relationship between neurocognition and metacognition provides vital information on cognitive pathways. Adequate neurocognition provides a necessary building block for the more complex process of metacognition (Lysaker et al., 2010); strong links between these processes indicate that neurocognition can be utilized for metacognitive tasks, whereas weak links suggest that neurocognitive abilities essential for metacognition cannot be engaged. A previous study from our group showed that links between neurocognition and metacognition break down when people with schizophrenia experience disorganized symptoms (Minor and Lysaker, 2014) and the current study found that conceptual disorganization drives this moderating effect. Thus, conceptual disorganization appears to disrupt metacognition in schizophrenia, in part, by weakening its relationship with neurocognition. In turn, this makes it more difficult for those experiencing conceptual disorganization to integrate intentions, thoughts, feelings, and

connections between events and form complex representations of themselves and others. Our observation is in line with classic and contemporary models of disorganization (Bleuler, 1911; Hardy-Bayle et al., 2003), including Bleuler's (1911) assertion that a "loosening of associations"—sharing many of the same attributes as conceptual disorganization—plays a key role in cognitive pathways. Future studies should account for conceptual disorganization when examining relationships between neurocognition and metacognition.

Taking the moderation finding a step further, we observed that conceptual disorganization has important ramifications for the limiting relationship of neurocognition on metacognition even at low levels of severity. Specifically, we found that significant links between neurocognition and metacognition were no longer present once minimal to mild conceptual disorganization was reached. In fact, this link essentially disappeared in a subgroup exhibiting moderate levels of conceptual disorganization. This suggests that treating conceptual disorganization could foster connections between neurocognition and metacognition, increasing the likelihood that one could engage in effective metacognition and improve functioning. An intervention that improves one's ability to integrate information—such as cognitive remediation (Mueller et al., 2015; Nuechterlein et al., 2014; see Saperstein and Kurtz, 2013) or metacognitive training (Bo et al., 2014; Ottavi et al., 2014) — may increase synchrony between neurocognition and metacognition in those with schizophrenia and should be a focus of future work.

Although conceptual disorganization played an important role in links between neurocognition and metacognition, the same did not hold true when exploring the neurocognition – social cognition relationship. Surprisingly, we found that no single disorganized symptom helped explain this relationship, which runs counter to previous findings that disorganized symptoms moderate relationships between neurocognition and social cognition (Minor and

Lysaker, 2014). The current finding could indicate that the moderating effect of disorganized symptoms is driven by a type of disorganization that was not assessed in this study. Another potential explanation is that a cumulative increase in disorganization, rather than in any single symptom, is responsible for weakening links between neurocognition and social cognition. The lack of support for our hypothesis signals contrasting clinical implications in how neurocognition is related to social cognition compared to metacognition. Whereas a specific treatment target was identified in the neurocognition – metacognition relationship (i.e., conceptual disorganization), interventions aiming to improve social cognitive functioning should focus on disorganized symptoms more broadly.

Strengths of this study included comprehensive assessments of neurocognition, social cognition, and metacognition, and a focus on how conceptual disorganization disrupts these cognitive pathways. In contrast to comprehensive cognitive assessments, one limitation of the study is that conceptual disorganization was only assessed using one clinician-rated item from the PANSS and no performance measure was used. Behaviorally-based instruments have shown promise for assessing disorganized symptoms across the schizophrenia-spectrum (Docherty, 2012; Minor et al., under review; Minor et al., 2015b; Minor and Cohen, 2010, 2012); future studies should investigate whether they provide further insight on the role of disorganization in cognitive pathways. Second, the choice of the MATRICS battery is a potential limitation as MATRICS subtests were chosen based on their relationship with functional impairments rather than disorganized symptoms. This may also explain the weak correlations between conceptual disorganization and neurocognition in the overall sample. A third limitation is that the scope of our data did not allow us to investigate directionality of our findings; one could also argue that metacognitive impairments give rise to conceptual disorganization or, conversely, that

conceptual disorganization precedes metacognitive impairment. Examining the direction of these relationships is an important issue of future study. Finally, most of the sample had been diagnosed with schizophrenia for many years; thus, a fourth limitation is that results may not generalize to recently diagnosed individuals. Although our study's focus was on chronic schizophrenia, future work should examine the role of conceptual disorganization at different points on the schizophrenia-spectrum (e.g., psychometric schizotypy, clinical high risk, first episode psychosis) to determine which stage effects emerge.

In sum, conceptual disorganization is a critical piece of the puzzle when disentangling relationships between neurocognition and metacognition, with links breaking down at low levels of severity. Roles of specific disorganized symptoms in the neurocognition – social cognition relationship were less clear. When aiming to improve cognitive impairments, findings from this study suggest that disorganized symptoms are important treatment considerations.

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Table 1.

Demographic and clinical variables of sample (n = 67).

Demographic	Mean	SD[1]
Age	50.49	10.46
Education	12.69	2.22
Annual Income	$908.64	$895.11
Male (%)	94.0	
Female (%)	6.0	
Caucasian (%)	37.3	
African-American (%)	61.2	
Other Race (%)	1.5	
Single (%)	46.3	
Married (%)	44.8	
Separated or Divorced (%)	9.0	
Clinical	**Mean**	**SD**
Age of First Hospitalization	28.90	12.19
Total Hospitalizations	5.12	4.80
Current Chlorprom. Equiv.[2]	382.96	419.29
Previous Alcohol Abuse (%)	19.4	
Previous Drug Abuse (%)	25.8	
Primary Measures	**Mean**	**SD**
Conceptual Disorganization	1.99	1.26
Neurocognition *t*-score	24.05	10.30

SocCog[3]: Emotion Proc[4] *t*-score	35.25	11.86
SocCog: Emotion Recognition	12.81	3.67
SocCog: TOM[5] (Hinting)	13.01	4.09
SocCog: TOM (SAT-MC[6])	11.39	4.18
Metacognition	11.34	3.89

NOTES: [1]SD: Standard deviation; [2]Chlorprom. Equiv.: Chlorpromazine equivalent; [3]SocCog: Social cognition; [4]Proc: Processing;[5]TOM: Theory of Mind; [6]SAT-MC: Social Attributions Test-Multiple Choice.

Table 2.

Conceptual Disorganization as a moderating variable in relationships between neurocognition, social cognition, and metacognition (n = 67).

	Social Cognition Composite				*Metacognition Total*			
	R^2	*B*	*SE B*	β	R^2	*B*	*SE B*	β
Overall Variance	0.27				0.15			
Neurocog Composite[1]		1.31	0.44	0.59**		0.67	0.21	0.67**
CogDisorg[2]		-0.59	0.20	-0.33**		-0.11	0.10	-0.14
Neurocog X CogDisorg		-0.23	0.17	-0.27		-0.20	0.08	-0.52*

NOTES: [1]Neurocog: Neurocognition; [2]CogDisorg: Conceptual Disorganization; **p < 0.01, * p < 0.05.

Figure(s)

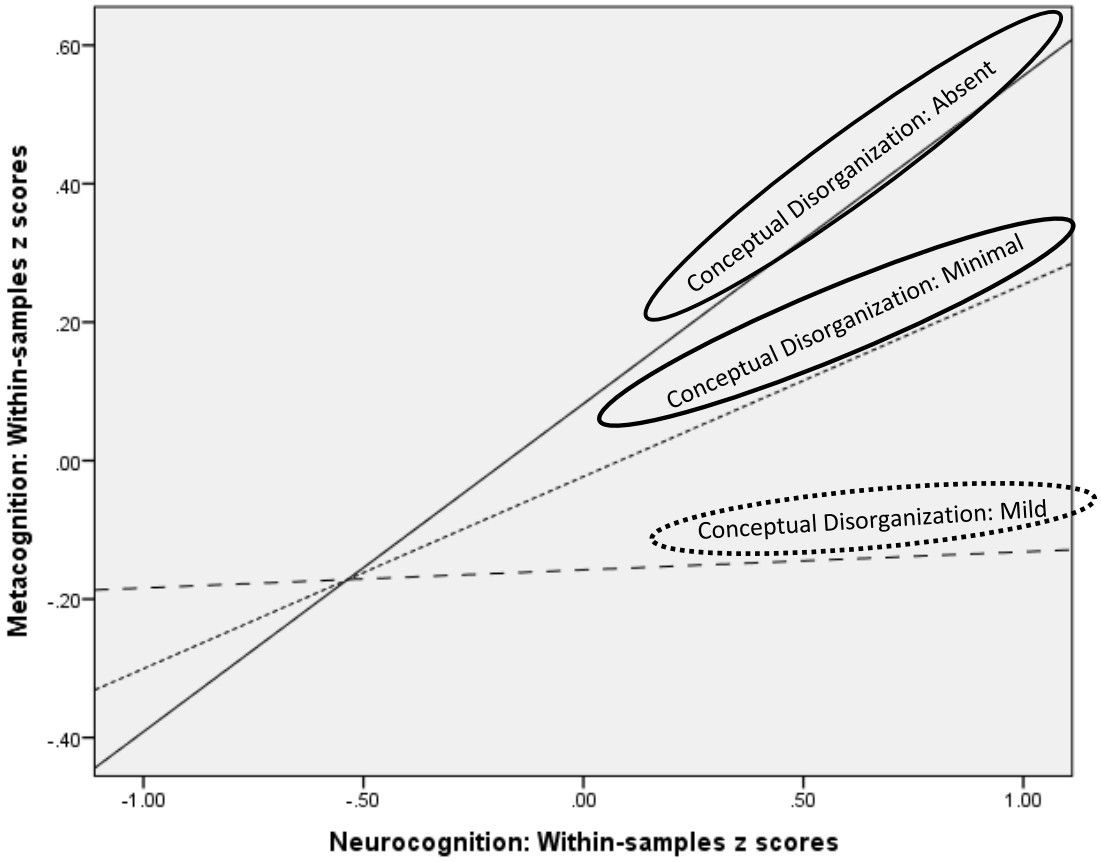

Fig. 1. The relationship between neurocognition and metacognition at different levels of conceptual disorganization.

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