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The role of social isolation and social cognition in thought disorder

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Highlights

- Social isolation was significant predictor of thought disorder.
- Performance on the hinting task fully mediated the relationship between social isolation and thought disorder.
- Indirect effects remained significant after controlling for comorbid psychotic experiences.
- In the final model, delusional beliefs significantly predicted thought disorder.

Title: **The role of social isolation and social cognition in thought disorder**

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ABSTRACT

2

A better understanding of how social factors relate to the psychological processes in thought disorder (TD) is necessary for the development of effective psychological interventions. Sixty-eight participants diagnosed with psychosis (18-65; 47.1% female) were recruited and evaluated on social cognition (Hinting Task, HT; and reading the mind in the eyes test, RMET), social isolation (size of social network, frequency and quality of contact), psychotic symptoms (Positive and Negative Syndrome Scale, PANSS) and TD (Thought, Language and Communication Disorders Scale, TLC). A mediation model was tested with isolation as the predictor, TD as the outcome, and performance on HT and RMET as the mediators. The final model, with adjustment for comorbid symptoms (i.e. delusions, suspiciousness, hallucinations, and negative symptoms), supported full mediation and explained a significant amount of the observed variance (60%). Performance on the HT was a significant mediator of the relationship between social isolation and TD. From the covariates, delusions contributed independently and significantly to TD. The implications of the findings for psychological practice, and TD-specific interventions, are discussed as well as the limitations of the study. Further avenues for symptom-specific research are discussed, in particular with reference to more complex psychosocial models.

1. Introduction

Formal thought disorder (TD) refers to a heterogeneous cluster of cognitive, linguistic, and communication atypicalities that renders speech difficult to follow and

at times unintelligible (Andreasen, 1979a, 1979b; Andreasen and Grove, 1986; Kircher et al., 2018). Amongst the most prevalent forms of TD are *tangentiality* (first example below)*, in which the speaker replies to a question in a way that is only vaguely related to the topic, and *derailment*, in which the speaker abruptly wanders off onto different and unrelated topics (second example below):

"[Interviewer: Strike while the iron is hot] It could mean [pause] Hercules! [Interviewer: Could you say more?] I saw the movie, Hercules. [Interviewer: Yes…] and it means don't iron over your hands and don't strike anybody before you cast the first stone" (Marengo et al., 1986; p. 498).

"[Interviewer: How are you?] To relate to people about new-found…talk about statistical ideology. Err…I find that it's like starting in respect of ideology, ideals change and ideals present ideology and…new entertainments…new, new attainments. And the more one talks about like, ideal totalitarianism or hotelatarianism, it's like you want new ideas to be formulated, so that everyone can benefit in mankind, so we can all live in our ideal heaven. Presumably, that's what we still want, and with these ideas, it can be brought about, I find the…it's like a rose garden" (Laws et al., 1999; p. 105).

TD is common in patients diagnosed with schizophrenia and psychotic-spectrum disorders but can be observed in other diagnostic groups (McKenna and Oh, 2005; Roche et al., 2014; Yalincetin et al., 2016). For many patients, TD is relatively enduring (Bowie et al., 2005; Harrow and Marengo, 1986; Marengo and Harrow,

4

1997). This is problematic since the presence of TD has been associated with poorer work (Racenstein et al., 1999) and social functioning (Bowie et al., 2011; Bowie and Harvey, 2008; Harrow and Marengo, 1986), poorer quality of life (Tan et al., 2014) and high rates of rehospitalisation (Harrow and Marengo, 1986; Wilcox, 1990). TD has also been found to have a negative impact on clinicians' ratings of the therapeutic alliance (Cavelti et al., 2016) a core process in effective cognitive behavioral therapy for psychosis (CBTp; Goldsmith et al., 2015). Moreover, TD has been found to be a significant predictor of future conversion into psychosis in high-risk populations (Bearden et al., 2011; Cannon et al., 2008; DeVylder et al., 2014; Ott et al., 2002). These findings make TD an important area of scientific enquiry and an interesting target for preventative work.

1.1. The role of social cognition in TD

The examples of *derailment* and *tangentiality* highlighted above occurred in a social and conversational context in which the patient showed an apparent failure to recognise that communication had gone awry. Consistent with this, TD patients do not tend to see their own verbalizations as idiosyncratic or difficult to follow, despite being able to successfully identify others' verbalizations as atypical or bizarre (Harrow et al., 1989). One possible explanation is that these patients may have an impaired 'theory of mind' (ToM or mentalization), the ability to understand the mental states of other people (Frith, 1992; Hardy-Baylé et al., 2003). This kind of impairment would make it difficult for the speaker to be aware of the beliefs and intentions of the interlocutor, which is necessary to guide and readjust the discourse to the needs of the listener when communication has gone awry (Pickering and Garrod, 2004), potentially resulting in communications being experienced by the listener as

tangential or *derailed*. Early studies that tested social inference through the use of vignettes portraying indirect speech acts (e.g. Corcoran et al., 1995), and a later meta-analysis on mentalization in psychosis (Sprong et al., 2007), were both consistent with a link between poor ToM and symptoms of TD and disorganization. For example, the latter review reported a substantial effect-size (ES) when comparing the performance of patients with disorganized symptoms and 'healthy' controls on mentalization tasks (d= −2.23). However, this finding does not establish a specific association between ToM and TD, as the analyses did not account for symptom comorbidity (ESs were also significant for patients without disorganization, paranoia, and in remission). Furthermore, the finding does not establish that ToM specifically is impaired in TD. Hence, Ventura and colleagues (2013) reported moderate ES for the association between both negative and disorganized symptoms and various socio-cognitive domains (not just mentalization or ToM).

1.2. Intermingling of personal concerns and worries in TD

Harrow and colleagues have suggested that the apparent bizarre and idiosyncratic quality of TD can also be explained by the intermingling into the patient's speech of personally salient concerns and worries that do not fit the 'external' context of the conversation (Harrow et al., 1983; Harrow and Prosen, 1978, 1979). They point out that delusions certainly qualify as personally salient concerns and worries of this kind (Lanin-Kettering and Harrow, 1985) and reported significant associations between delusional beliefs and the presence of TD in patients (Harrow and Quinlan, 1985; Harrow et al., 1983). These findings were interpreted as supporting the hypothesis that patients with prominent TD stray from the 'external' context of the conversation (Harrow et al., 2000) as they mix in to their conversation decontextualized personal

worries and concerns, including delusional ideas (Harrow et al., 1983), an effect that seems to be true not only for thought-disordered patients diagnosed with schizophrenia but also for patients diagnosed with other diagnoses (Harrow et al., 2003). This hypothesis is, in fact, consistent with the hypothesis of impaired ToM, as intermingling would be expected to occur when the speaker is unaware of the needs of the listener.

1.3. Social isolation

Other researchers have suggested that social isolation may be an important factor in the development and maintenance of psychotic experiences. For example, Hoffman (2007) suggested that social withdrawal and isolation during critical developmental periods could lead to deafferentation-like effects in the brain regions that support the generation of complex social meaning, consequently facilitating psychotic experiences in vulnerable individuals. Freeman and colleagues have suggested that social isolation might be an important factor in the maintenance of persecutory beliefs since it deprives individuals of crucial disconfirmatory feedback from others (Freeman and Garety, 2006; Freeman, 2007; Freeman et al., 2002).

Although most of the studies of social isolation and psychosis carried out to date have not focused on specific symptoms, a large corpus of findings has accumulated showing that patients diagnosed with psychotic-spectrum disorders have higher rates of social isolation (Hirschberg, 1985), loneliness (Michalska da Rocha et al., 2017), smaller social networks (Erickson et al., 1989; Macdonald et al., 2000), fewer confidants (Morgan et al., 2008), and contacts within their networks (Reininghaus et al., 2008). These characteristics appear to predate the onset of psychosis (Gayer-Anderson and Morgan, 2013) and do not seem to represent a

'network crisis' in response to the onset illness. For example, in a longitudinal survey study, Wiles and colleagues (2006) reported that smaller social networks at baseline were a significant predictor of the likelihood of self-reported psychotic experiences 18-months later. Similarly, Malmberg and colleagues (1998) reported that, in a large sample of 50,054 Swedish conscripts, those individuals who had reported having fewer than 2 friends and preferred smaller groups were significantly more likely to have developed psychotic experiences 15-years later. Birth cohort studies have also identified social isolation in childhood as being significantly associated with later diagnosis of schizophrenia (Cannon et al., 2002; Jones et al., 1994; Welham et al., 2009).

1.4. Social isolation and TD

Very little research has been carried out on environmental and social factors specifically associated with the development and maintenance of TD (Bentall et al., 2014). TD has been assumed to be the expression of a discrete neuroanatomical deficit (e.g. *left superior temporal gyrus*; Sumner et al., 2018) perhaps originating from genetic vulnerabilities (e.g. *FOXP$_2$*; Levy et al., 2010). However, it is important to acknowledge that TD (manifested in communication with others) occurs in an environmental context and that emotional and social factors are crucial for understanding its development and maintenance. For example, there is a considerable volume of research documenting the impact of stress or arousal of negative affect on TD in patients (de Sousa et al., 2016; Docherty, 1996).

We have previously reported a significant and sizable relationship between TD, measured during a purposely-designed set of interviews, and self-reported social isolation (de Sousa et al., 2015). Importantly, this relationship remained significant

when we controlled for comorbid psychotic symptoms (i.e. hallucinations, and suspiciousness). Horan and colleagues (2006) have also reported significant correlations between thought disturbance, in patients diagnosed with schizophrenia, and smaller social network size (along with other network-related variables). Badcock and colleagues (2015) reported a significant association between subjective ratings of TD in psychotic patients and loneliness and suggested that isolation might contribute to the maintenance of TD by taxing already depleted cognitive and executive resources in psychotic patients. We interpreted these findings as suggesting that social isolation may play an important role in both the maintenance and development of TD. In this context, it is important to note that several studies have reported significant relationships between isolation and poorer executive processes, social cognition, and more general cognitive processes in non-psychotic patients (Cacioppo and Hawkley, 2009). We hypothesized that lack of social interaction (social feedback; Hammer et al., 1978) and conversational opportunities in patients could have an impact on their ability to successfully keep to the 'external' conversational context with others.

1.5. The present study

The preceding review of the literature has highlighted that TD is a social phenomenon, in which failures of conversation alignment occur when the affected individual is preoccupied with salient (possibly delusion-related) thoughts and lacks the social cognitive skills to recognise the listener's failure to follow the conversation. We have suggested that the relevant social cognitive deficits may develop in the context of social isolation. In the present study, we conducted a preliminary test of this model by testing the following specific hypotheses: (1) TD would be predicted by social isolation after adjustment for comorbid symptoms (negative symptoms,

delusions, suspiciousness, and hallucinations); (2) poor performance on social cognitive tasks will be specifically associated with TD; and (3) the statistical effect of social isolation on TD will be mediated by performance on social cognitive tasks after adjusting for comorbid symptoms. Given the previous finding of Harrow and colleagues that delusions were associated with TD, we also considered this association in our analyses.

2. Methods

2.1. Participants

Sixty-eight participants were recruited from local mental health services across the North West of England. Participants were originally identified and approached by care coordinators or nursing staff. The recruitment targeted individuals 18-65 years of age, who had a primary diagnosis of a psychotic-spectrum disorder as determined by their responsible clinicians (e.g. schizophrenia, schizoaffective disorder, or unspecified non-organic psychosis, see Table 1). All participants were deemed to have the capacity to consent to take part in research (as assessed by care coordinator, or responsible clinician). Excluded from the study were individuals with a diagnosis of moderate to severe learning disability; neurological or any other organic conditions that could significantly impact on cognitive performance; or who had a diagnosis of substance misuse disorder. All participants were provided with information about the study and time to decide if they were willing to take part. A £10 voucher was offered to all participants as a sign of appreciation for their contribution.

2.2. Measures

2.2.1. Psychotic symptoms

10

Psychotic symptoms were assessed with the *Positive and Negative Syndrome Scale* (PANSS; Kay et al., 1987). The PANSS is a 30-item semi-structured clinical interview that requires 45-50 minutes to administer. The scale is composed of 7 positive (e.g. hallucinatory behaviour or suspiciousness), 7 negative (e.g. blunted affect or emotional withdrawal) and 16 general symptoms (e.g. lack of judgement and insight or poor impulse control). Each item is scored on a severity scale of 1 (absent) to 7 (extreme) with overall scores ranging from 30 to 210. The scale has been widely used in both research and clinical settings and has good psychometric properties (Kay et al., 1987).

2.2.2. Thought disorder (TD)

TD was scored with the *Scale for the Assessment of Thought, Language and Communication Disorders* (TLC; Andreasen, 1986). The TLC is a well-established scale that provides definitions and scores for 18 cognitive, linguistic and communicational atypicalities. The scale was developed to be applied to any speech sample (e.g. clinical interviews). The different items are scored on a scale of severity ranging from 0 to 4 or 0 to 3 (depending on the item). Global ratings are achieved by summing the scores of the individual items. Some items are considered "more pathological" (e.g. derailment or clanging) and others "less pathological" (e.g. loss of goal or blocking) with former scores being multiplied by 2. The scale has been widely used in research and has good psychometric properties (Andreasen, 1979a).

2.2.3. Social isolation

Social isolation was measured with the *Lubben Social Network Scale - 18* (LSNS; Lubben, 1988). The LSNS is a self-report questionnaire that measures the size,

11

closeness, and frequency of social contacts using 18 items that cover three domains of social networks (family, neighbours, and friends). The scores for each question range from 0 to 5 with total scores ranging from 0 to 90 with the higher scores representing higher social integration (we reversed the scores for ease of interpretation). The instrument has good psychometric properties (Lubben and Gironda, 2004) and has been previously used with individuals diagnosed with psychotic-spectrum disorders (de Sousa et al., 2015).

2.2.4. Reading the Mind in the Eyes test (RMET)

The RMET (Baron-Cohen et al., 2001) is a task that measures the ability to discriminate mental states in others. The task is based on 36 grey-scale edited pictures (plus one extra practice trial) of males (19) and females (17) that only show the eye region of the face. In each picture, the participant is presented with 4 mental state terms (e.g. bored, arrogant, flustered, etc.) and ask to choose and circle the word that best describes what the individual in the picture is thinking or feeling (1 target and 3 foil words). The overall score is calculated by adding the number of correct answers and can range from 0 to 36. The RMET (revised version) has been used extensively in studies with patients diagnosed with schizophrenia (Bora et al., 2009) and has been shown to have good validity and test-retest reliability (Fernández-Abascal et al., 2013; Vellante et al., 2013).

2.2.5. Hinting task

The Hinting task (Corcoran et al., 1995) was designed to test the ability to infer intentions from indirect speech acts. The task consists of 10 vignettes depicting everyday social interactions that are read out loud. Each vignette ends with a

character dropping a hint (e.g. Paul has to go to an interview and he's running late. While he is cleaning his shoes, he says to his wife, Jane: "I want to wear that blue shirt but it's very creased."). The participant is then asked to make an inference about what is being implicitly conveyed. If the answer is correct the participant is given a score of 2. If the answer is not correct than a second hint is given (e.g. Paul goes on to say: "It's in the ironing basket."), if the answer is then correct the participant is given a score of 1 or 0 if he fails to infer the implicit communication. Overall scores are calculated by summing up the scores for each vignette and range from 0 to 20. The task has been extensively used in research settings and has been found to have strong psychometric properties (Pinkham et al., 2016).

2.3. Statistical analyses

Means, standard deviations, counts, and percentages for the study variables, as well as *t*-tests, ANOVA and an exploratory matrix of bivariate correlations, were all computed on IBM SPSS (version 24.0). The latter analysis was carried out to test some of the basic assumptions necessary to test mediation (Baron and Kenny, 1986). The *p*-value of the correlations was adjusted with Bonferroni correction to reduce the risk of type I errors (i.e. the cut-off of the *p*-value was set at $\alpha=0.05/n_{\{number\ of\ comparisons\}}$). Inter-rater reliability (IRR) for TD scores was estimated with Intra-class correlations (ICC). Mediation analysis was tested using PROCESS macro (version 3.0; Hayes, 2013) with social isolation (X) as the predictor, TD as the dependent variable (Y), and the Hinting task and RMET as mediators (M). The final model was adjusted for three covariates (delusions, hallucinations, suspiciousness, and negative symptoms) and R^2 was used to measure goodness-of-fit. The significance of indirect effect (95% CI) was tested using bootstrap estimation with 10000 samples (Hayes,

2013). Finally, we tested the same model separately for positive and negative TD. Symptoms were clustered using the data from Andreasen's original factorial analysis (Andreasen, 1979b).

2.4. Procedure

Participants were initially asked for demographic (e.g. age, marital status, etc.) and clinical information (e.g. current medications and dosages). They were then interviewed with the PANSS (30-45 minutes), which was recorded, with the participants' consent, using a digital voice recorder (Sony ICD-PX312). All the interviews were carried out by the first author (P.S.) who is trained on the PANSS interview and scoring procedure. The interviews were not only used to assess symptoms but also to later code for TD using the TLC (Andreasen, 1986). Following the PANSS, participants were asked to complete the LSNS, the Hinting task and finally the RMET. The whole procedure did not take more than 90 minutes and all participants were offered the possibility of breaks after each task had been completed.

For the purposes of establishing IRR, first (P.S.) and third authors (A.E.) independently scored ≈10% (7) of the interviews. First author is a psychologist (PhD) with a significant amount of clinical experience in adult mental health and the third author is an assistant psychologist (graduate) with clinical experience in acute mental health care. The coding was preceded by the careful reading of the TLC, relevant papers and by ongoing discussions. For some items, it was not possible to calculate reliability because they were too infrequent (e.g. neologisms, clanging, etc.) for the remaining TLC items Intra-class correlations were all substantial (ICC > 0.75).

3. Results

3.1. Demographics and clinical variables

Table 1 shows the means, standard deviations, and counts for the main demographic and clinical variables in the study. Our participants were predominantly White British, single and unemployed. There was a significant representation of participants with a diagnosis of 'other psychosis' perhaps reflecting patients under the care of local Early Intervention Services (these teams take a more symptom-focused approach to treatment).

******INSERT TABLE 1 HERE******

3.2. TD and clinical and demographic variables

There were no significant differences in TD across sexes (t= 0.678, n.s.), marital status (t= -1.34, n.s.), work status (t= -1.35, n.s.), or diagnostic group ($F(3,64)$= 2.64, n.s.). TD was also not correlated with age (r= 0.177, n.s.), or years of education (r= -0.125, n.s.). However, the relationship with medication was significant (chlorpromazine equivalents: r= 0.238, p= 0.05) with higher levels of TD being associated with higher levels of anti-psychotic medication.

3.3. Relationships amongst variables of interest

Table 2 below shows an exploratory correlation matrix for the primary variables in our study. Importantly, TD was found to correlate significantly with social isolation and both socio-cognitive measures. Social isolation was correlated with the latter measures but not with the negative scale of the PANSS. The strength and significance of these relationships satisfied the basic conditions to test a mediational model.

15

It is worth noting the substantial correlation between conceptual disorganization (item P2 from the PANSS) and the TD score. Also of relevance is the significant correlation between TD and the PANSS delusions score and the non-significant relationships between both PANSS delusions and PANSS suspiciousness and the socio-cognitive measures (although, the relationship between suspiciousness score and the hinting task was nearly significant, $p= 0.064$). The significant relationship between the negative PANSS scale and the socio-cognitive measures has been reported in previous studies (e.g. Ventura et al., 2013).

******INSERT TABLE 2 HERE******

3.4. Mediation Model

Multiple regression analyses were carried out to test each path of the proposed mediation model with adjustment for scores on hallucinations, delusions, suspiciousness, and negative symptoms. First, we found that social isolation was a strong predictor of TD (B= 0.302, $t(62)= 3.87$, $p < 0.001$). Second, social isolation was a strong predictor of both performance on the Hinting task (B= -0.126, $t(62)= -4.32$, $p < 0.001$) and RMET (B= -0.170, $t(62)= -3.86$, $p < 0.001$). Lastly, performance on the Hinting task (B= -1.301, $t(60)= -4.23$, $p < 0.001$), but not RMET (B= -0.319, $t(60)= -1.57$, $p = 0.123$), was a significant predictor of TD. Adding Chlorpromazine equivalents as a covariate did not change the model in any substantive way and therefore it was not included in the final model.

Because both a, and one of the b paths (Hinting task) were significant, we tested for mediation using bootstrapping with bias-corrected confidence estimates. The 95% confidence intervals for the indirect effects were estimated with 10000

bootstrapped resamples as recommended in the literature (Hayes, 2013). The results of the analyses confirmed that performance on the Hinting task (B= -1.272 CI= -1.847 to -0.623) but not on the RMET (B= -0.335, CI= -0.716 to 0.015), mediated the relationship between social isolation and TD. Importantly, of the four covariates, the delusions item remained as a significant and independent predictor of TD (B= 3.776, $t(60)$= 4.405, $p < 0.001$; bootstrapped: 3.765 CI= 2.002 to 5.655). In addition, the direct effect between social isolation and TD (c'), after adjustment for covariates and mediators, became non-significant supporting full mediation (B= 0.084, $t(60)$= 1.103, $p = 0.275$). The final model was highly significant and explained 60% of the effect ($F(7,60)$= 12.588, $p < 0.001$). Figure 1 shows the coefficients for the different paths of the mediation model.

******INSERT FIGURE 1 HERE******

3.5. Positive and negative TD

Because TD is a highly heterogeneous construct, we ran the same model using negative (poverty of speech and poverty of the content of speech) and positive (pressure of speech, derailment, incoherence, illogicality, word approximations, circumstantiality, loss of goal, perseveration, clanging, distractible speech, and stilted speech) TD as dependent variables. The composite scores were assembled according to the factor loadings from Andreasen's original factor analysis (1979b).

The first model, with negative TD as the dependent variable, was not significant. Path's c (social isolation to negative TD) and b (HT and RMET to negative TD) were all non-significant. However, the second model, with positive TD as the dependent variable, was significant. Path c, with social isolation predicting

17

positive TD was highly significant (B= 0.155, $t(60)$= 4.03, $p < 0.001$), as were the path b between HT and positive TD (B= -0.545, $t(60)$= -3.444, $p = 0.001$) but not RMET (B= -0.174, $t(60)$= -1.661, n.s). Path c' was also non-significant (B= 0.057, $t(60)$= -1.448, n.s.) supporting full mediation (R^2= 0.548; $F(7,60)$= 10.402, $p < 0.001$).

3.6. Medication effects

In order to test if high TD caused physicians to raise medication dose leading participants to feel lethargic and more socially isolated, we ran a separate model with TD as the predictor, Chlorpromazine equivalents as the mediator, and social isolation as the outcome variable. As expected, path c linking TD to social isolation was highly significant (B= 0.618, $t(66)$= 4.222, $p < 0.001$). However, path a linking TD and Chlorpromazine equivalents was non-significant (B= 5.266, $t(66)$= 1.994, p= 0.0503) as was path b linking Chlorpromazine equivalents to social isolation (B= -0.002, $t(65)$= -0.263, p= 0.793). Finally, path c' remained highly significant (B= 0.628, $t(65)$= 4.134, $p < 0.001$) leading to a significant model (R^2= 0.214; $F(2,65)$= 8.823, $p < 0.001$).

4. Discussion

First and foremost, the present study found significant and robust associations between social isolation, poor performance on social cognitive tasks, and TD. The relationship between poor performance on mentalization and TD has been previously investigated (Frith, 1992; Hardy-Baylé et al., 2003; Sprong et al., 2007). However, it is interesting to note that the relationships with both RMET and the Hinting task were

substantial and that the correlation between the tasks and both the PANSS delusion and suspiciousness items did not reach significance.

The latter point is important because previous studies have reported significant associations between paranoia and ToM performance (Sprong et al., 2007). The relationship between social isolation and TD was more interesting. First, it replicates previous findings from our own and other research groups (Badcock et al., 2015; de Sousa et al., 2015), and second, in contrast to what has previously been suggested (Freeman et al., 2002; Hoffman, 2007) neither hallucinations nor delusions or suspiciousness correlated with social isolation (it is unclear why unusual beliefs did not correlate with social isolation. One possibility is social isolation may be specifically associated with strength of conviction and other variable rather than unusual beliefs). These findings by themselves suggest some degree of symptom specificity. Also relevant was the significant association between the delusions item and TD, which we will discuss in more detail below. Before addressing our mediation model, it is important to mention the substantial association between RMET and Hinting task. The strength of the association supports the hypothesis that, despite using distinct methodologies (social inference from indirect speech acts as opposed to emotion recognition from facial expressions), both tasks may measure the same construct, as has been suggested in the literature on social cognition in schizophrenia (e.g. Browne et al., 2016).

However, the overall goal of the study was to test if the statistical effects of social isolation on TD were mediated by performance on the social cognitive tasks (and if the indirect effects survived the adjustment for comorbid symptoms). Our findings supported a full mediation model, with the relationship between social isolation and TD (path c') losing significance when performance on the social

19

cognitive tasks was entered in the model. This result, along with the strength of the indirect effects in our model, suggests that the relationship between independent and dependent variable was in great part accounted for by the performance of the hinting task, but not so clearly by performance on the RMET. This is interesting given that hinting task could be assumed to target perspective-taking more specifically. Also relevant is that the indirect effects survived the adjustment for comorbid symptoms. This is especially important given that poor performance on social cognition has been previously reported to be associated with negative symptoms in patients diagnosed with schizophrenia (Ventura et al., 2013). In our model, our indirect effects remained highly significant after adjustment for this symptom group, supporting specificity with TD. It is worth mentioning that other TD-focused studies have also reported substantial and specific associations between TD and poor mentalization through the analysis of ToM performance across symptom-contrasted subgroups (e.g. Sarfati et al., 1997). It is also relevant to highlight that the sub-analyses for both negative and positive TD showed that the mediation only worked for the later group of symptoms (there was no relationship between social isolation, HT and RMET and negative TD in the model). This finding is important because it suggests that social isolation and poor social cognition are particularly relevant in positive rather than negative TD.

Perhaps more importantly, in our final model the PANSS delusions item remained a robust and independent predictor of TD. This finding is by no means unique, Harrow and colleagues have reported similar associations between delusions and scores on the bizarre and idiosyncratic thinking (BIT) scale in patients diagnosed with psychotic-spectrum disorders (Harrow et al., 1983; Harrow and Quinlan, 1985; Lanin-Kettering and Harrow, 1985). The authors argued that during communication, TD patients, due to poor perspective taking and heightened arousal (Harrow et al.,

1989), tend to intermingle personal concerns and worries, such as delusional beliefs, into their speech making their communications sound bizarre and idiosyncratic (Harrow et al., 1983; Harrow et al., 2003). It follows that during moments of heightened arousal, the ability to mentalize (along with other psychological processes) may become depleted leading to the intrusion of decontextualised concerns and worries (Harrow et al., 1989), and to an unawareness, on the patient's part, that communication has gone awry. Such hypothesis is consistent with our own findings that mentalization and delusional beliefs make independent contributions to TD but also with evidence that TD worsens when patients are asked to talk about emotionally salient topics (de Sousa et al., 2016).

On a more speculative level, we would suggest that in TD the ability to model the interlocutor's mind (ToM) may be particularly important when other automatic multi-level priming processes have failed in conversation, and alignment needs to be repaired (Pickering and Garrod, 2004). We would suggest that this may be especially pertinent for instances of tangentiality and derailment where cooperative principles of communication have broken down. In these cases, TD may emerge from a particular difficulty in dynamically and interactively repairing one's communication and meet the communicational needs of the listener. Consistent with this, the correlations between social cognition (HT and RMET) and tangentiality and derailment were sizable and highly significant as was the analysis with positive TD as the dependent variable.

We suggest that TD patients may be particularly vulnerable due to chronic social isolation and lack of exposure to dialogue and social feedback. In this case, social isolation would be both an important predisposing and maintaining factor for TD as suggested by other authors (Badcock et al., 2015). We are not suggesting that

social isolation is a sufficient condition for TD, but rather that social isolation, in combination with other psychological and affective processes (e.g. negative affect; de Sousa et al., 2016), may be a necessary condition to increase the likelihood of TD through its impact on social cognition. Chronic social isolation and social withdrawal (ubiquitous in prodromal stages) may have a deleterious effect on socio-cognitive development in psychotic patients. Although our study does not test this hypothesis directly, these ideas are consistent with findings from studies that tested the impact of social isolation on social cognition in non-psychotic participants (Cacioppo and Hawkley, 2009). In future studies, it would be important to test these hypotheses by prospectively testing the cumulative impact of social isolation on both mentalization and TD in patients diagnosed with schizophrenia. Another avenue for research would be to experimentally test the impact of negative affect, or cognitive load, on mentalization and TD.

4.1. Limitations

The present study has methodological, statistical, and conceptual limitations. At a statistical level, the relatively small N limits confidence in the findings. It would be important to replicate the study with a larger N and inclusion of other domains of social cognition (e.g. social perception, and emotion recognition). At a conceptual level, it could be argued that other domains of social cognition, not assessed in this study, may be equally important to understand disordered communication or TD in psychosis. Perhaps, more importantly, is the issue of the interpretation of the direction of effects. In our study, we set our hypotheses and mediation model, theoretically, and we tested its validity by exploring the significance of the indirect effects along with the goodness-of-fit. However, this does not preclude other interpretations given that

22

the study tested mediation with cross-sectional data. For example, it is possible that increased TD may lead to higher social isolation (i.e. social distance and avoidance) and poorer performance on social cognition (i.e. poor executive ability). However plausible, this interpretation of the results would not account for other important findings in the field of psychosis. For example, ToM and more generally speaking socio-cognitive difficulties have been shown to be prevalent in individuals at risk of psychosis (Van Donkersgoed et al., 2015) suggesting that these difficulties are present long before the onset of psychosis; the same is true for social isolation (Gayer-Anderson and Morgan, 2013). Children and young people who are later diagnosed with schizophrenia tend to display higher rates of social isolation (see introduction).

4.2. Clinical implications: from the lab to therapy

The findings of the present study have important implications for clinical practice. At one level, they support that social isolation is an important predictor of TD. Therefore, it would be important for current CBTp models of TD (e.g. Palmier-Claus et al., 2017) to incorporate specific strategies to enhance the social networks and conversational opportunities of patients. Another possibility would be to use existing social network interventions (e.g. Terzian et al., 2013) alongside individual CBTp. At another level, we would suggest that difficulties with social cognition could be addressed by complementing therapy with interventions that target poor ToM and mentalization. For example, there is evidence to support the effectiveness of social cognitive training programmes in schizophrenia (e.g. Kurtz et al., 2016). Packages focusing on context appraisal and perspective-taking could be particularly helpful for highly isolated TD patients (e.g. social cognition enhancement training; Choi and Kwon, 2006).

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Conflicts of interest

None.

Contributors

P. Sousa, W. Sellwood, and R. Bentall were responsible for study concept and design. P. Sousa collected all the data and carried out the statistical analyses (under the supervision of W. Sellwood and R. Bentall) and along with A. Eldridge coded speech samples. P. Sousa was responsible for drafting the manuscript and W. Sellwood and R. Bentall for the critical revision. All authors accepted the final version.

Ethical standards

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional guides on the care and use of laboratory animals.

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Figure 1 – Unstandardized coefficients (B) for the different paths in the meditation model

(not bootstrapped).
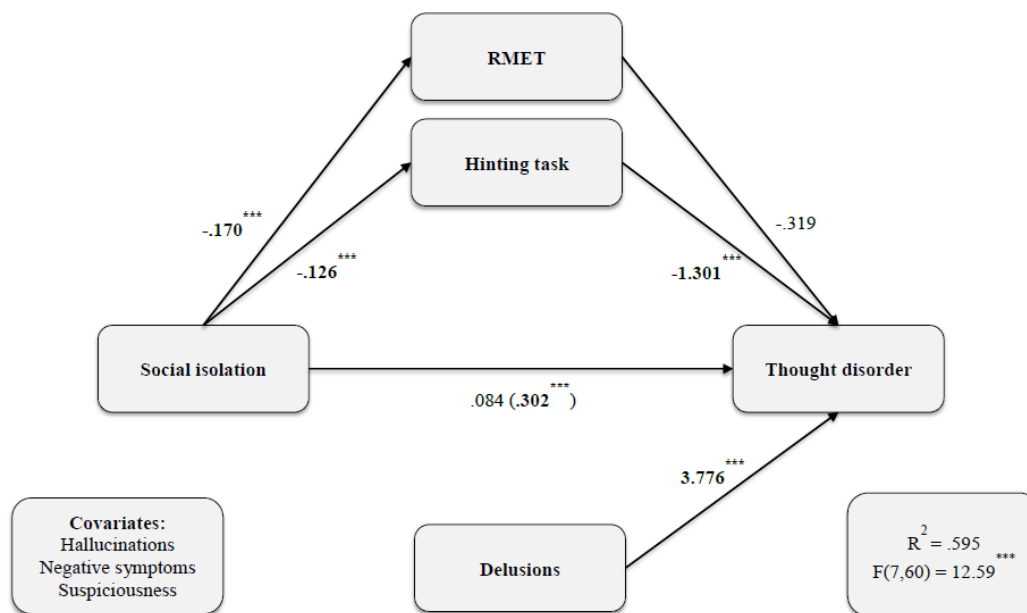
Note: * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Variable		Mean (s.d.)/count (%)	Min	Max
Sex	Male	36 (52.9%)		
	Female	32 (47.1%)		
Age		38.4 (13.15)	18	64
Education (years)		11.5 (2.18)	8	18
Marital status	Single	57 (83.8%)		
	Married	10 (14.7%)		
	Divorced	1 (1.5%)		
Employment status	Unemployed	58 (85.3%)		
	Employed	7 (10.3%)		
	Student	2 (2.9%)		
	Other	1 (1.5%)		
Ethnicity	White British	53 (77.9%)		
	Other British	5 (7.4%)		
	White Irish	3 (4.4%)		
	European	3 (4.4%)		
	Arab	2 (2.9%)		
	African	2 (2.9%)		
Diagnosis	Schizophrenia (F20)	27 (39.7%)		
	Schizoaffective (F25)	20 (29.4%)		
	Delusional disorder (F22)	3 (4.4%)		

	Other psychoses (F29)	18 (26.5%)		
Anti-psychotic medication	FGA[1]	23 (33.8%)		
	SGA[2]	45 (66.2%)		
Chlorpromazine equivalents (mgs)		319.7 (282.2)	0	1465
	Positive (7-49)	20.7 (7.2)	7	35
PANSS	Negative (7-49)	17.8 (6.3)	7	39
	General (16-112)	46.5 (9.9)	25	69
	Total (30-210)	84.9 (18.7)	42	132
Thought disorder (TLC)		12.1 (12.8)	0	46
Social isolation (0-90)		63 (17.1)	17	90
Hinting task (0-20)		15.2 (4.8)	1	20
RMET (0 - 36)		21.1 (6.9)	4	33

[1] First generation antipsychotics
[2] Second generation antipsychotics

Table 1. Demographic and clinical variables.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Hallucinations (P3)										
2. Delusions (P1)	0.347**									
3. Suspiciousness (P6)	0.237	**0.702*****								
4. Conceptual disorganization (P2)	0.134	**0.473*****	0.274*							
5. Negative symptoms (PANSS)	0.377**	0.351*	0.231	0.209						
6. Isolation (LSNS)	-0.121	0.098	0.025	0.334**	0.201					
7. Hinting task	-0.119	-0.209	-0.226	**-0.623*****	**-0.439*****	**-0.503*****				
8. RMET	-0.132	-0.187	-0.093	**-0.424*****	**-0.395*****	**-0.474*****	**0.605*****			
9. TD (TLC)	0.035	**0.450*****	0.248	**0.894*****	0.217	**0.461*****	**-0.622*****	**-0.514*****		
10. Tangentiality	-0.036	0.351*	0.151	**0.779*****	0.163	0.323*	**-0.552*****	**-0.471*****	**0.824*****	
11. Derailment	0.021	**0.441*****	0.225	**0.863*****	0.129	0.367*	**-0.502*****	**0.431*****	**0.898*****	**0.717*****

**   **

Note: Values highlighted in **bold** represent significance after Bonferroni correction $p < 0.001$ (alpha= $1-0.95/53$).

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Table 2 - Bivariate correlations between PANSS symptoms, social isolation, socio-cognitive tasks, and TD.