The relationship between jumping to conclusions and neuropsychological functioning in schizophrenia

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ABSTRACT

Jumping to conclusions (JTC) is defined as a tendency to make decisions based on insufficient information. JTC has been reported in patients with psychosis, but the mechanisms of this cognitive bias remain unknown. The main aim of our study was to investigate the relationship between JTC and neuropsychological functioning in schizophrenia. A total of 85 schizophrenia patients were assessed with neuropsychological tests, including executive functions, verbal memory, working memory, processing speed and attention. JTC was assessed with the Fish Task (probability 80:20 and 60:40) and a self-report scale (The Davos Assessment of Cognitive Biases Scale, DACOBS). Symptom severity was assessed with the Positive and Negative Syndrome Scale (PANSS). The relationship between JTC and neuropsychological functioning was investigated with correlation and regression analyses. The regression analyses model, when controlling for duration of illness, age and symptoms, showed that verbal memory and working memory were specifically related to JTC measured by Fish Task 60:40. JTC measured using Fish Task 60:40 was correlated only with severity of symptoms of disorganization (PANSS). The results from the present study suggest that the relationship between decision making during the reasoning task and neuropsychological functioning is modulated by task demands.

1. Introduction

Jumping to conclusions (JTC) is a tendency to make decisions hastily, on the basis of little evidence. This cognitive bias may explain both the genesis and maintenance of a number of non-elaborated delusional beliefs (Garety et al., 2001) where delusions emerge based on indirect or fallible evidence, e.g. the belief that the secret service is spying on an individual because the telephone is making strange noises. The JTC bias is mostly assessed with a probabilistic reasoning task, i.e. the "beads task" (Garety et al., 2005; Huq et al., 1988), in which participants are asked to request information in the form of colored beads drawn from one of 2 jars in order to make a decision about the jar of the beads' origin. Recent studies and reviews have argued for the superiority of a categorical definition of JTC as a decision made after viewing fewer than 3 beads (Garety and Freeman, 2013). When assessed in this way, the bias is reliably found in ca. 40% of people with delusions (Bentham et al., 1996; Falcone et al., 2015) as compared to 20% of the non-clinical sample (Freeman et al., 2008). It suggests that people with psychosis have a tendency to make a decisions with certainty based on insufficient information.

Recently, independent meta-analyses (Dudley et al., 2016; McLean et al., 2017; Ross et al., 2015; So et al., 2016) have confirmed the importance of JTC for delusions by showing its specific relation to these symptoms. Indeed, several studies showed that patients with delusions have a greater tendency to jump to conclusions than people without mental disorders or with other mental disorders (Conway et al., 2002; Dudley et al., 2016; Garety et al., 2005). Although, most studies have found a clear relationship between delusions and JTC, some studies showed that hallucinations and proneness to hallucinations are related to JTC, but not delusions (Ochoa et al., 2014). Menon et al. (2008) found that global positive symptoms ae related to JTC more than delusional symptoms. JTC is more frequent among people in remission and at risk of psychosis (Broome et al., 2007; Freeman et al., 2008; Van Dael et al., 2006). Although, studies to date have demonstrated that JTC is reliably replicated across several clinical populations with delusions (Dudley et al., 2016), as well as in high risk subjects (Broome et al., 2007) and relatives of patients (Van Dael et al., 2006), the mechanisms of this cognitive bias remain poorly understood. However, some studies have suggested that JTC may be independent of positive symptoms and may be related to neurocognitive deficits

(Woodward et al., 2009). The question about relationship of JTC with cognitive domains is still an open question toward which our study may provide new insights. Knowledge about neurocognitive mechanisms of JTC could be helpful to design better clinical interventions for patients who suffer from psychosis—interventions directed at improving reasoning biases like meta-cognitive training would benefit from incorporating cognition-enhancing tasks.

To date, only limited studies have attempted to investigate neurocognitive mechanism of JTC providing inconclusive results. For instance, it was found that patients with lower general intelligence scores performed worse in JTC tasks (Bentham et al., 1996; Van Dael et al., 2006). However, this association was not confirmed in other studies (Lincoln et al., 2010). Some studies have found relationship between impaired functioning in working memory tasks with grater predisposition to JTC (Broome et al., 2007), however, opposite findings were found by others (Buck et al., 2012). Ochoa et al., (2014) found that participants who jump to conclusions had significantly worse performance on verbal memory task compered with participants without JTC bias. Previous studies showed also that executive functioning is associated with JTC (Ochoa et al., 2014; Rubio et al., 2011; Woodward et al., 2009). Recent study demonstrated that JTC is present even in early stages of the schizophrenia, and there was a relationship between JTC and attention, psychomotor speed, working memory and executive functioning (Gonzalez et al., 2018).

There is substantial evidence that people with schizophrenia not only lack insight into their psychiatric symptoms (David et al., 2012) but also their neurocognitive deficits (Balzan et al., 2012). It is therefore likely that patients may also show poor metacognitive awareness of the cognitive biases that may be contributing to their delusional symptoms, however the evidence regarding the cognitive insight is inconsistent (Guerrero and Lysaker, 2013; Kother et al., 2012). These inconsistencies highlight the need to assess the relationship between subjective and objective cognitive biases in parallel, in order to determine if metacognitive awareness of such distortions is impaired. A more recent research tradition investigates cognitive biases by means of questionnaires like the Cognitive Biases Questionnaire for Psychosis (CBQ-P) (Peters et al., 2014) and the Davos Assessment of Cognitive Biases Scale (DACOBS) (van der Gaag et al., 2013), which evaluate subjective awareness of cognitive biases among patients with psychosis. Recent studies have found that self-reported cognitive biases, including JTC, are related to psychosis and its risk states (Gaweda and Prochwicz, 2015; Gaweda et al., 2017a, b, c). There is evidence suggesting that some psychological interventions such as Metacognitive Training have demonstrated that JTC can be reduced by being aware of its presence (Aghotor et al., 2010; Moritz et al., 2015; Pankowski et al., 2016) and in consequence minimized intensity of positive symptoms (Waller et al., 2015) and improved the quality of life (Andreou et al., 2014; Moritz et al., 2011a).

The findings on the role of cognitive biases have been transferred to psychological interventions for patients with psychotic symptoms (Moritz et al., 2011a). However, still little is known about mechanisms of cognitive biases in psychosis. In particular, neurocognitive mechanisms of cognitive biases are poorly understood. In the consequence, although some interventions on cognitive biases have been found effective (Pankowski et al., 2016) it is still not well explored how to integrate them with interventions focusing on neurocognition (Cognitive Remediaton Therapy, CRT). In this context, a better understanding of the relationships between cognitive biases and neurocognitive functions may be beneficial.

1.1. The present study

Given the fact that the results from studies on the relationship between JTC and neuropsychology functioning are inconclusive, the neurocognitive mechanisms of JTC continue to remain unknown. Only limited studies (Garety et al., 2013; Ochoa et al., 2014) have addressed

the relationship between JTC and a wide range of neurocognitive functioning as assessed with comprehensive batteries of neuropsychological tests. Furthermore, the neurocognitive mechanisms of subjective awareness of JTC have not been investigated so far.

Our study was intended to fill some of the aforementioned gaps in the field. First, our primary aim was to assess the relationship between JTC and a wide range of neuropsychological functioning in people with schizophrenia. We used two different tasks of JTC (80:20 and the more difficult 60:40) and a self-report scale for JTC. Furthermore, given that JTC was considered a cognitive mechanism of psychotic symptoms, we considered symptom severity in the analyses.

2. Material and methods

2.1. Participants

A total sample of 85 (44 females and 41 males) patients with an established diagnosis of schizophrenia, recruited from in- and outpatients (departments that cooperated with the II Department of Psychiatry, Medical University of Warsaw, Poland), took part in the study after written informed consent had been obtained. The inclusion criteria were ICD-10 criteria for schizophrenia and patients aged between 18 and 65; the mean age of our sample was 42.20 years (SD = 11.42). Eighty-three patients were diagnosed with paranoid schizophrenia, one with undifferentiated schizophrenia, one with residual schizophrenia and one with simple schizophrenia. The diagnosis was based on a clinical interview conducted by a licensed psychiatrist and was confirmed by the Neuropsychiatric Interview MINI 5.0 (Sheehan et al., 1998) for the purpose of the study. Patients with acute psychotic symptoms, agitation or aggressive behaviors were excluded. All patients who took part in the study were being treated with antipsychotic medications. Patients with equivocal diagnosis, a history of illicit substance and alcohol abuse (with no illicit drug use within 6 months), previous brain injury or intellectual disability were excluded from the study. The study was approved by the Ethics Committee of the Medical University of Warsaw.

2.2. Evaluation

2.2.1. Jumping to conclusions—objective assessment

JTC was assessed using a computerized probabilistic reasoning task similar to Beads Task (Moritz et al., 2009; Speechley et al., 2010) which differs from the original task in that a different scenario (lakes with fish instead of jars with beads) is displayed.

We used two versions of the probabilistic reasoning task which varied in terms of the discrimination ratio. The first version had a high discrimination ratio (80:20) with unambiguous evidence, whereas the second was more difficult with fish in low discriminability (60:40) with more ambiguous evidence. The instructions were standardized and presented on a computer screen. After each fish was "caught" the participant was required to make two judgments: (1) a probability judgment about the likelihood that the fish was caught from either lake A or lake B, and (2) a judgment as to whether the available amount of information would justify a decision or not. It was emphasized that the fish would be caught from the same lake throughout the entire experiment. The ratio of fish in each lake was displayed along with previously caught fish in order to minimize the influence of working memory. Jumping to a conclusion was defined as a premature decision after one or two fish had been caught. In the correlational and regression analyses we considered JTC as Draw to Decision (DTD), because of we were interested in tendencies in data gathering biases.

2.2.2. Jumping to conclusions—subjective assessment

The Davos Assessment of Cognitive Biases Scale (van der Gaag et al., 2013) was used to measure jumping to conclusions bias. The DACOBS consisted of 42 items sub-grouped into seven dimensions (jumping to

conclusions; belief inflexibility bias; attention for threat bias; external attribution bias, social cognition problems; subjective cognitive problems; safety behaviors). The beads task was used to validate the 'Jumping to conclusions' subscale.

2.2.3. Neuropsychological functioning

- Color Trails Test (CTT) (D'Elia et al., 1994; Łojek and Stańczak, 2012) was used to assess selective attention, mental flexibility, visuospatial skills and motor speed. The CTT-1 requires that the individual connect numbers in an ascending order from 1 to 25 as quickly as possible. The variable included in the analysis was the time of test completion (in sec).
- Forward Digit Span from the WAIS-R (PL) (Brzeziński et al., 2004) was used to assess the short-term memory. The Backward Digit Span subtest was used to assess the working memory. The variable included in the analysis was the total number of lists reported correctly.
- Block Design Test from the WAIS-R was used to evaluate eye-hand coordination, analytic and synthetic abilities and the ability to re-organize one's own actions. The variable included in the analysis was the total score (accuracy in matching the pattern and speed in completing each item).
- D2 Test of Attention (Brickenkamp et al., 2010) was used to test attention factors concerning the speed of perception, mistakes, overall perception ability (speed factor in relation to the number of mistakes) and alertness. The test requires that participants cross out distinctively marked letters "d" in lines comprising diversely marked letters "p" and "d". The variable included in the analysis was the sum of the number of characters processed before the final cancellation on each trial minus the sum of all errors of omission and commission.
- California Verbal Learning Test (CVLT, Delis et al., 2000) was used to measure verbal learning and memorizing abilities. Participants memorized words from the A List, repeating the words 5 times immediately after their presentation. The variable included in the analysis was the total number of words recalled in all trials (1–5).
- Wisconsin Card Sorting Test (WCST, Heaton et al., 1993) was used to measure executive functions described as supervisory, control and cognitive activity management functions. The WCST consists of 2 decks of cards, 64 cards each. Participants have to match each card from the deck with one of four model cards. Participants choose the matching procedure based on information received after each match (right or wrong). The variables included in the analysis were categories completed, perseverative errors and non-perseverative errors.

2.2.4. Symptoms

The severity of schizophrenia symptoms was assessed with the Positive and Negative Syndrome Scale (PANSS) (Kay et al., 1987), which is a semi-structured interview assessing 30 symptoms on a 7-point scale, from 1 (absent) to 7 (extreme). Symptoms are rated over the past 7 days. Psychometric properties can be considered adequate to good (Kay et al., 1987; Kay et al., 1987; Peralta and Cuesta, 1994; Santor et al., 2007). The 5-factor solution to the PANSS (van der Gaag et al., 2013) was used in this study, providing factor scores for positive symptoms, negative symptoms, disorganization, excitement and emotional distress.

2.2.5. Statistical analysis

Data analysis was conducted using the 24.0 version of the SPSS. Correlations among variables were analyzed by using Pearson's correlation coefficients with Bonferroni correction for multiple comparisons. Three separate linear regression analyses were conducted to assess the relationship between neuropsychological domains and JTC 60:40, JTC 80:20 and JTC as assessed in the DACOBS. Please note that the number of patients that jumped to conclusions was reported if the decision was

Table 1
Sample characteristics.

	N	%
Gender		
Male	44	(51.8%)
Female	41	(48.2%)
Professional situation		
Studies	3	(3.5%)
Works	14	(16.5%)
Unemployed	11	(12.9%)
Rent	55	(64.7%)
Work and rent	2	(2.4%)
JTC 80:20*	38	(45%)
JTC 60:40*	27	(32%)
	Mean	**SD**
Age	42.20	(11.43)
Duration of illness (years)	15.72	(10.23)
Medication (average dose of chlorpromazine)	475.32	(343,32)
CVLT	50.76	(11.08)
WCST number of categories	2.40	(1.38)
WCST perseverative errors	13.27	(8.72)
WCST non-perseverative errors	9.86	(7.06)
D2WZminB	322.68	(89.28)
CTT 1	65.69	(27.40)
CTT 2	119.19	(46.56)
Block Design	24.58	(10.90)
Forward Digit Span	5.89	(1.88)
Backward Digit Span	5.41	(1.78)
PANSS		
Total Score	43.85	(10.28)
Positive	9.75	(4.41)
Negative	12.90	(4.97)
Disorganization	7.39	(3.22)
Excitement	6.18	(2.66)
Emotional distress	7.81	(2.74)
DACOBS		
Total Score	161.01	(30.99)
Jumping to Conclusions	25.07	(5.73)
JTC 80:20**	3.94	(3.08)
JTC 60:40**	5.64	(3.81)

Note: JTC*jumping to conclusion –decision after viewing fewer than 3 fish, JTC** jumping to conclusion- number of fish to making decision, CVLT—California verbal learning test—sum; WCST—Wisconsin card sorting test; D2—test of attention; CTT 1 and CTT 2—color trial test 1 and 2—time of execution was calculated in seconds.

made for 1 or 2 fish (dichotomous variable). However, in the correlational and regression analyses we considered the amount of information gathered before the decision was made (continuous variable). Independent variables included in the regression models were those neuropsychological variables that were significant at a level of $p < 0.05$ in the correlational analysis. In addition, we entered into the regression models confounders that significantly correlated with the dependent variable in order to control their influence. Thus, if it was justified, regression analysis was performed in three steps. In the first step the age and duration of illness were entered into the model as control variables. In the second step, psychiatric symptoms measured by the PANSS were included, and in the third block, neuropsychological variables were added into the regression model. Multicollinearity among the variables was examined using the VIF indicator. VIF values below 3 were considered as a sign of non-multicollinearity.

3. Results

3.1. Characteristics of the sample

The characteristics of the participants are presented in Table 1. There were no statistically significant differences between men and women in JTC ($p > 0.05$).

Table 2
Correlations between JTC measured using the Fish Task and other variables.

Variable	JTC 60:40	JTC 80:20	DACOBS JTC
CVLT	**0.434****	**0.294****	− **0.307****
Block Design	**0.504****	**0.343****	−0.040
Forward Digit Span	**0.305****	**0.252****	−0.121
Backward Digit Span	**0.340****	**0.220****	− **0.236***
WCST number of categories	**0.317****	0.190	−0.167
WCST perseverative errors	− **0.319****	−0.058	0.118
WCST non-perseverative errors	−0.075	−0.145	0.009
D2WZminB	**0.351****	0.179	−0.063
CTT 1	− **0.398****	− **0.240***	0.176
PANSS positive	−0.173	−0.044	**0.300****
PANSS negative	−0.130	−0.051	−0.010
PANSS disorganization	− **0.272***	−0.192	**0.319****
PANSS excitement	−0.201	−0.167	**0.357****
PANSS emotional distress	0.030	0.025	− **0.268***
PANSS total	− **0.240***	−0.121	**0.241***
Age	− **0.387****	−0.130	−0.065
Duration of illness (years)	− **0.322****	−0.087	0.101

Note: Bold and underlined values are significant after Bonferroni correction for multiple comparisons.
CVLT—California verbal learning test—sum; WCST—Wisconsin card sorting test; D2—test of attention; CTT 1 and CTT 2—color trial test 1 and 2—time of execution was calculated in seconds.
* $p < 0.05$.
** $p < 0.01$.

3.2. Relationship between neuropsychological functioning and JTC

Correlational analyses with a Bonferroni correction for multiple comparisons showed no relations between self-reported JTC and neuropsychological functions and that these functions related more to JTC as assessed with the Fish Task with a lower discrimination ratio (60:40), as compared to the high discriminability version. The highest correlations were found between JTC 60:40 and the results of tests such as Block Design, CVLT, Backward Digit Span, D2 and CTT 1. With respect to the JTC measured by the 80:20 Fish Task version, it had only one moderate negative relationship with Block Design. JTC as assessed with a self-measure and by both Fish Tasks displayed correlations with other neuropsychological functions as well, although they turned out to be insignificant when the Bonferroni correlation was considered. The results are presented in Table 2.

As can be observed in Table 2, JTC measured by the 60:40 Fish Task version showed a larger number of moderate associations with neuropsychological variables as compared with the 80:20 version of this task. JTC on the first task version was significantly related to lower performance, particularly in Block Design, CVLT, CTT, D2 and Digit Span. With respect to the JTC measured by the 80:20 Fish Task version, it had the strongest although still moderate negative relationship with Block Design.

Self-reported JTC turned out to be negatively correlated with CVLT and Backward Digit Span, indicating that a higher tendency to jump to conclusions was related to a weaker working memory and verbal learning. However, these relations were insignificant after Bonferroni correction. The results are presented in Table 3. Subjective and objective JTC correlated only in 60:40 Fish Task ($r = -0.26$; $p > 0.05$).

3.3. Relationship between schizophrenia symptoms and JTC

After Bonferroni correction for multiple comparison, only self-reported JTC showed a significant relation with the PANSS excitement subscale.

3.4. Regression

There was no multicollinearity among variables included in the

Table 3
Hierarchical regression analysis: relation between JTC 60:40 and neuropsychological tests controlling for age and duration of illness among patients with schizophrenia ($n = 85$).

Step		JTC 60:40	
		B	β
1	Age	−0.119	− **0.372***
	Duration of illness	−0.024	−0.067
2	Age	−0.125	− **0.388***
	Duration of illness	−0.017	−0.047
	PANSS disorganization	−0.334	− **0.290***
3	Age	−0.052	−0.162
	Duration of illness	−0.008	−0.023
	PANSS disorganization	−0.211	−0.183
	Block Design	0.079	0.230
	CVLT	0.109	**0.319***
	CTT 1	−0.021	−0.152
	Forward Digit Span	0.427	**0.211***
	Backward Digit Span	−0.169	−0.079
	D2WZminB	−0.008	−0.190
	WCST number of categories	0.269	0.101
	WCST perseverative errors	−0.030	−0.070

Note: Separate analyses were conducted for JTC 60:40, JTC 80:20 and the DACOBS JTC subscale.
* $p < 0.05$.

regression analysis (VIF < 3).

3.4.1. The relationship between JTC 60:40 and neuropsychological variables

At first we conducted hierarchical linear regression with JTC measured by Fish Task 60:40 as a dependent variable. Variables were entered in three steps. In the first step we entered the age and duration of illness as variables to be controlled. Then in a separate block we also included disorganization as a PANSS subscale. In the next stage eight predictors were entered: Block Design, Forward Digit Span, Backward Digit Span, CVLT, WCST – number of categories, WCST—perseverative errors, CTT 1 and D2. The regression analysis suggested that the neuropsychological variables predicted JTC above the symptoms of disorganization, as it turned out to be insignificant in the final block. In the final model only two, i.e. CVLT and Forward Digit Span, emerged as significant predictors of JTC 60:40. The overall model significantly explained 37% of the variance and fit the data well: $F (11, 68) = 5.24$; $p < 0.001$. Statistics for individual predictors are summarized in Table 4. In addition, we conducted regression analysis with JTC as categorical variable. We defined 'jumping to conclusion' as making decision after one or two fishes in the Fish Task. Results showed that only CVLT remained significant ($B = -0.096$; $p < 0.05$).

3.4.2. The relationship between JTC 80:20 and neuropsychological variables

Next we conducted second linear regression with JTC measured by Fish Task 80:20 as the dependent variable and Block Design, CTT 1, CVLT, Forward Digit Span and Backward Digit Span as predictors. None of the control variables or PANSS subscales from our previous regression analysis correlated significantly with the outcome variable, thus

Table 4
Regression model for JTC measured by Fish Task 80:20 ($n = 85$).

	JTC 80:20	
	B	β
Block Design	0.068	0.240
CVLT	0.061	0.221
CTT 1	−0.007	−0.060
Forward Digit Span	0.296	0.181
Backward Digit Span	−0.109	−0.063

Table 5
Hierarchical regression analysis with self-reported JTC as a dependent variable.

Step		DACOBS JTC	
		B	β
1	PANSS positive	0.334	**0.259**[*]
	PANSS excitement	0.546	**0.255**[*]
	PANSS disorganization	0.320	0.181
	PANSS emotional distress	−0.761	**−0.365**[**]
2	PANSS positive	0.325	**0.252**[*]
	PANSS excitement	0.556	**0.259**[*]
	PANSS disorganization	0.255	0.144
	PANSS emotional distress	−0.739	**−0.355**[**]
	Backward Digit Span	−0.414	−0.130

[*] $p < 0.05$.
[**] $p < 0.001$.

we did not include them in this model. The regression results showed that neither neuropsychological functions nor symptom severity were significant predictors (the results are presented in Table 4). In regard to regression analysis with JTC as dichotomous dependent variable, two of the predictors: CVLT ($B = −0.067$; $p < 0.05$) and Block Design ($B = −0.084$, $p < 0.05$) turned out to be significant.

3.4.3. The relationship between self-reported JTC and neuropsychological variables

In the third step we conducted hierarchical linear regression for self-reported JTC. We examined Backward Digit Span as the neuropsychological predictor, also including in the regression model those PANSS subscales that correlated significantly with the dependent variable (Disorganization, Positive, Excitement and Emotional Distress). Only Positive, Excitement and Emotional Distress turned out to be significant predictors. This model significantly ($F(6,77) = 6.79$; $p < 0.001$) explained 29% of the variance; see Table 5 for detailed results.

4. Discussion

In the present study we wanted to investigate the relationship between jumping to conclusions as assessed independently with objective and subjective measures and its relation to neuropsychological functioning in patients with schizophrenia. We also considered the relationship between jumping to conclusions and symptoms of schizophrenia. The present study demonstrates the relationship between decision making during the reasoning task and neuropsychological functioning is modulated by task demands. Our results suggest that both objective and subjective measures may have different relations to neuropsychological deficits and symptoms.

In line with previous studies (Huq et al., 1988; Fear and Healy, 1997; Dudley et al., 1997; Conway et al., 2002; Garety et al., 2005), we found that 45% of patients showed JTC on the 80:20 and 32% on the 60:40 Fish Task version. Our results show that the relationship between JTC and neuropsychological functioning depends on the type of assessment (objective vs subjective) and the difficulty of the fish task. More specifically, and similarly to a previous study (Ochoa et al., 2014), our correlation analyses revealed that when participants faced the task with a lower discrimination ratio (60:40), the tendency to gather less information before the final decision was made was related to a wider spectrum of cognitive domains. As shown in the final regression model when controlling for duration of illness, age and symptoms, working memory as assessed with CVLT and Forward Digit Span turned out to be significant predictors. On the other hand, none of these relations were significant when considering JTC as assessed with Fish task 80:40 and subjective JTC. Our results showed that the relationship between neuropsychological variables and JTC was different in the categorical variable (jumpers and not jumpers) than numerical (DTD). In regressional analysis with continuous JTC 80:20 none of the predictors was statistically significant, but after making JTC 80:20 a dichotomous

variable two neuropsychological predictors (CVLT and Block Design) reached significance. In regard to analysis of regression with JTC 60:40 as dichotomous dependent variable only one of the two neuropsychological predictors (CVLT) remained significant. Previous results showed higher relationship between neuropsychological functioning and JTC in the categorical variable (Falcone et al., 2015, Gonzalez et al., 2018), however our approach relied on continuous variables because of we were interested in tendencies in data gathering biases. With regard to the relationship between JTC and clinical symptom severity, we found that patients with higher severity of disorganization made a significantly more hasty decision on the 60:40 task, although this relationship turned out to be insignificant after neuropsychology variables were considered. No other relations between symptoms and JTC were found.

Our results suggest that a more demanding task (60:40) is associated with neuropsychology functioning, particularly with working and verbal memory. This is consistent with a previous study (Garety et al., 2013) which showed an association between JTC and impairments in the working memory (Letter—Number Sequencing and Digits), and more strongly in the difficult task (60:40). This may suggest that difficulties with data gathering may exert more influence when the task is more demanding (a less discriminable ratio; more ambiguous evidence). This is consistent with the line of research showing that patients with schizophrenia underperform in cognitively demanding tasks (Bora et al., 2010).

On the other hand, although subjective JTC measured by the DACOBS scale was correlated only with the working memory (Digit Span), this relationship turned out to be insignificant when controlling for duration of illness, age and symptom severity. This may suggest that reasoning biases, particularly when they are demanding, as measured with objective tasks, have different neurocognitive underpinnings than awareness of these biases (Moritz et al., 2016).

This difference between objective and subjective measures of the JTC may also be observed with regard to relationships with symptom severity, e.g. we found that it is severity of disorganization and not delusions or other symptom dimensions that are related to JTC as assessed with a more demanding JTC task, although it should be noted that the relationship was no longer significant after Bonferroni correction for multiple comparisons. Most studies have found a relationship between delusions and JTC (Conway et al., 2002; Dudley et al., 2016; Fear and Healy, 1997; Garety et al., 2005; Gaweda et al., 2017c; Huq et al., 1988). The relationship between disorganization and JTC turned out to be insignificant after including neurocognitive functioning; hence it seems that it is a decline in the verbal working memory that is of particular importance for JTC during a demanding reasoning task, even when the symptoms are considered. In terms of a clinical interpretation, these findings suggest that when faced with higher ambiguity during the decision-making process, patients with higher disorganization exhibiting a higher degree of verbal working memory deficits tend to be prone to make hasty or inadequate decisions.

Simultaneously, our hierarchical regression analysis showed that positive symptoms, contrary to objectively assessed JTC, are related to subjective JTC, i.e. they turned out to be a significant predictor both before and after including neuropsychological variables to the regression. This corresponds to numerous research studies which showed that subjective JTC bias is related to delusions (Gaweda and Prochwicz, 2015) and hallucinations (Daalman et al., 2013). Excitement and emotional distress were also significant predictors. This reflects recent findings which showed that elevated stress increases proneness to poor decision making among psychotic patients with delusions (Moritz et al., 2015). The dissociation in the relationship between objective and subjective JTC and positive symptoms might be a result of assessment characteristics. In a self-report scale patients have to remember situations in which they made hasty decisions, thus the probability of recognizing such situations is higher, whereas in behavioral task patients make a decision in the present moment. One

possible explanation why we did not find a relationship between objective JTC and positive symptoms is that the PANSS score of our patients was relatively low. Our sample was not limited to patients with active delusions and the literature reviews and meta-analysis showed that JTC was associated with an increase in delusion severity (Dudley et al., 2016; McLean et al., 2017). Future studies are required to investigate the relationship between objective and subjective measures of cognitive biases and their relation to symptoms.

The results of the study may be of clinical importance. Our results indicate that patients with psychosis overestimate their reasoning capacities and rationality. Hence, therapy should include attempts to raise patients' insight about cognitive distortions to balance objective and subjective functioning (to attenuate confidence and to engage in further information seeking in case of insufficient evidence) (Moritz et al., 2016). The neuropsychological deficits of patients with schizophrenia may be linked to inadequate decision-making processes that increase the likelihood of cognitive biases, specifically JTC. Our results suggest that patients with cognitive deficits may be particularly prone to JTC in demanding situations. The line of research confirmed that psychological interventions such as cognitive remediation and meta-cognitive training could improve the working and verbal memory and could be useful in reducing JTC bias (Farreny et al., 2012; Moritz et al., 2015, 2011b; Penades et al., 2010; Wykes et al., 2007). In light of our results it might be advisable to combine cognitive remediation techniques with those interventions that focus on cognitive biases (e.g. meta-cognitive training). Cognitive behavioural therapy for psychosis and cognitive remediation are evidence-based approaches, and that each intervention targets different but complementary aspects of schizophrenia, so the two therapies may benefit from being combined in the clinical practice (Naeem, 2017; Balzan, 2017).

4.1. Strengths and limitations

Our study was conducted among an adequate sample of schizophrenia patients and we used both subjective and objective measures to assess JTC along with a comprehensive assessment of neuropsychological functioning; hence we were able to investigate the complex relationship between JTC and cognitive deficits. However, the conclusions from our study should be made in light of the study's limitations. First, the beads task and its modifications have been criticized as being poorly reliable and prone to numerous influences, including comprehension difficulties (Balzan et al., 2012; Moritz et al., 2006). Thus future studies may benefit from using a new task that has been designed to overcome some of these difficulties (Moritz et al., 2017). Research with samples drawn from different stages of illness, including at-risk, early and treatment resistant groups, and with a greater range in symptomatology, is required to replicate and extend these findings. Greater clarity regarding neuropsychological impairments associated with the JTC bias should also pave the way for theoretically grounded studies investigating the neuropsychological mechanism of JTC, e.g. using neuroimaging. Finally, the relationship between symptom severity and JTC should be targeted by including more patients with active delusions.

4.2. Conclusions

To conclude, the results of the present study suggest that the relationship between decision making during the reasoning task and neuropsychological functioning is modulated by task demands. In particular, verbal working memory deficits are implicated in more hasty decision making when the task is demanding, even after controlling for confounding effect of age, length of illness as well as severity of symptoms. On the contrary, hasty decisions made in a less demanding task are independent of cognitive deficits. Finally, our results suggest that both objective and subjective measures may have different relations to neuropsychological deficits and symptoms, with the latter being more related to symptom severity.

Contribution

ŁG and MK designed the study; AK helped in recruiting patients; MK and BB collected the data; RP and MK performed the data analyses; ŁG and MK interpreted the results; MK wrote the first draft of the manuscript; and ŁG edited the manuscript. All authors approved the final version of the article.

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