Neuropsychological functioning and jumping to conclusions in delusions ☆

Philippa Garety [a],[*], Eileen Joyce [b], Suzanne Jolley [a], Richard Emsley [c], Helen Waller [a], Elizabeth Kuipers [a], Paul Bebbington [d], David Fowler [e], Graham Dunn [c], Daniel Freeman [f]

[a] Department of Psychology, Institute of Psychiatry, King's College London, London, UK
[b] Institute of Neurology, University College London, London, UK
[c] Centre for Biostatistics, Institute of Population Health, Manchester University, Manchester, UK
[d] Mental Health Sciences Unit, Faculty of Brain Sciences, University College London, London, UK
[e] School of Medicine, Health Policy and Practice, University of East Anglia, East Anglia, UK
[f] Department of Psychiatry, Oxford University, Oxford, UK

ARTICLE INFO

ABSTRACT

Background: It has been consistently demonstrated that delusions are related to jumping to conclusions (JTC), a data-gathering bias and potential candidate endophenotype of psychosis. Recent research suggests that JTC may be a marker of treatment response. However, we know little about the factors contributing to the occurrence of this reasoning bias. This study investigated the relationship between JTC and hypothesised deficits in working memory, employing standard well-validated neuropsychological tests, in people with current delusions.
Method: One hundred and twenty six people with schizophrenia spectrum psychosis and current delusions were assessed for current symptoms, and tested for JTC. We compared performance on tests of working memory in those with the reasoning bias and those without.
Results: As expected, 30–40% of this sample of people with current delusions showed the JTC bias. There were no differences in premorbid IQ between those with and without the JTC reasoning bias. However, the performance of the JTC group was significantly worse on tests of working memory.
Conclusions: The JTC data-gathering bias is associated with impairments in working memory. New non-pharmacological interventions for people with delusions, designed to improve data gathering, may benefit from incorporating strategies to overcome deficits in working memory.

1. Introduction

1.1. Delusions and jumping to conclusions

Over the last decade, delusions have become a focus of cognitive theories and empirical research and are considered to result from a number of interacting biological, psychological and social factors (Freeman et al., 2002; Kapur, 2003; van der Gaag, 2006; Garety et al., 2007). One factor highlighted has been reasoning biases (Bentall et al., 2001; Rector and Beck, 2001; Garety et al., 2005; Moritz and Woodward, 2007). Delusions have been shown with particular consistency to be associated with reduced data gathering; this 'jumping to conclusions' (JTC) bias may be considered a promising candidate endophenotype of psychosis (see reviews by Garety and Freeman, in press; Freeman, 2007; Fine et al., 2007). A tendency to use fewer data to reach a decision is held to contribute to delusion formation and persistence; thus, it is proposed that anomalous or ambiguous information is rapidly appraised and a delusional conclusion drawn, on the basis of limited evidence, and without a thorough consideration of alternatives.

Reduced data gathering in individuals with delusions has been repeatedly demonstrated using probabilistic reasoning tasks based on a Bayesian model of probabilistic inference (Garety et al., 1991; Dudley et al., 1997; Moritz and Woodward, 2005; Peters and Garety, 2006; van Dael et al., 2006; Menon et al., 2008; Peters et al., 2008). Approximately 40% of people with delusions jump to conclusions (JTC) on an easy version of the task—that is demonstrate an extreme data gathering bias (Garety et al., 2005). The JTC bias has been replicated widely, using various modifications of the basic paradigm, not only in people with delusions, but also in people who have recovered from delusions, people at risk of delusions, and people with delusion proneness in the general population (see recent reviews Garety and Freeman, in press; Moritz and Woodward, 2007; Freeman, 2007; Fine et al., 2007). JTC is not changed by antipsychotic medication (Peters and Garety, 2006; So et al., 2012) but has been shown, in first episode psychosis, both to moderate the short-term response to anti-psychotic treatment (Menon et al.,

2008) and to predict longer term outcome over two years (Dudley et al., in press), such that those with JTC showed poorer outcomes. It may therefore serve as a marker of treatment response. Accordingly, psychological interventions which attempt to modify JTC have started to emerge in the literature (Moritz et al., 2010).

1.2. Possible mechanisms for the JTC bias

JTC is a data-gathering bias, but other reasoning mechanisms contributing to it are not yet clear, and a wide variety of proposals have been made. Some hypotheses involve motivation, affect, specifically anxiety or further thinking biases, for all of which, at present, the evidence is inconclusive, while others invoke neurocognitive deficits (Fine et al., 2007; Freeman, 2007; Merrin et al., 2007; Moritz et al., 2007; So et al., 2008; Lincoln et al., 2010; Lunt et al., 2012).

The probabilistic reasoning task involves a process of data gathering and decision making which includes holding in mind and updating bead sequences (working memory). This executive function could, therefore, contribute to JTC. Furthermore, JTC may be viewed as an intermediate 'resource sparing strategy' (Beck and Rector, 2005), which would also justify the investigation of working memory processes, since they serve to manage the control of attentional processes (Baddeley, 2000; Burgess and Simons, 2005) and, like data gathering biases, are associated with decisiveness and functioning in real life (Green, 1996; McKay et al., 2007).

The evidence with respect to neurocognition is quite limited. Broome et al. (2007) found an association of JTC with impaired working memory, and Young and Bentall (1995) noted that patients with delusions have difficulty processing sequential information. More recently, Bentall et al. (2009), using structural equation modeling, found that JTC appeared to be related to paranoia via a cognitive functioning factor, which was partially composed of tests they considered to reflect executive functioning, including a test of working memory (backward digit span). Woodward et al. (2008) found that JTC was associated with executive functioning (rule extraction). However, other studies linking JTC with memory or other cognitive impairments, including impulsivity, have been inconclusive (e.g., Dudley et al., 1997; Moritz and Woodward, 2005; Langdon et al., 2008; van Hooren et al., 2008; Lunt et al., 2012; Ormrod et al., 2012).

The relationship of JTC to the well-attested cognitive impairments of schizophrenia is therefore uncertain. Although working memory deficits are very well established as related to schizophrenia (e.g., Horan et al., 2008; Ventura et al., 2009), it should be noted that JTC differs from cognitive impairments in schizophrenia in that, unlike them, it is specifically related to delusional symptoms. The accumulating evidence of a possible relationship of JTC with working memory suggests that this should now be investigated systematically.

1.3. Aim and hypothesis

The aim of the study was to test the hypothesis that the jumping to conclusions bias is related to deficits in working memory in people with psychosis and current delusions, using standard well-validated tests. We also investigated whether JTC is related to other domains of cognitive functioning, specifically processing speed and verbal learning, as these are also commonly impaired in schizophrenia. Premorbid IQ was additionally estimated as an index of general cognitive ability.

2. Methods

2.1. Participants

The participants were drawn from a cohort of one hundred and sixty individuals with current delusions and a schizophrenia-spectrum disorder recruited from mental health services in London and Norfolk, UK, for studies involving experimental randomized investigations of interventions to improve delusions. The current study reports on baseline

prerandomization data only. Inclusion criteria were a diagnosis of schizophrenia, schizoaffective or delusional disorder; a current delusion held with at least 50% self-rated conviction; aged 18 to 65 years; and fluency in English. Individuals were excluded if they had a primary diagnosis of alcohol or substance dependence, organic syndrome or learning disability or a profound visual impairment. Of the 160 participants in the cohort, 34 participants were excluded from the current study because of additional factors considered to invalidate the neuropsychological test results (English reported to be a second language ($n = 15$); participants with premorbid IQ score below 70 ($n = 15$); and participants with self-reported dyslexia ($n = 4$)). The final sample therefore comprised 126 participants with current delusions.

2.2. Design and procedure

The study was cross sectional. In order to test our hypotheses of a relationship between JTC and impaired performance on the neuropsychological tests, the sample was grouped by whether they displayed the JTC bias. Trained assessors administered all the clinical assessments and the neuropsychological tests.

2.3. Measures and tasks

2.3.1. Psychotic symptoms: the Scale for the Assessment of Positive Symptoms (SAPS) and the Scale for the Assessment of Negative Symptoms (SANS)
The SAPS and SANS are widely used and well-validated semi-structured interviews designed to assess positive and negative psychopathology over the past month (Andreasen, 1984a,b). For the current study, the global ratings were summed to create a total score for each measure.

2.3.2. Depression and anxiety: the Beck Depression Inventory (BDI-II) and the Beck Anxiety Inventory (BAI)
The BDI-II is a self-report scale designed to assess symptoms of depression occurring over the past 2 weeks (Beck et al., 1996). The Beck Anxiety Inventory is a self-report scale, for the assessment of anxiety over the previous week (Beck et al., 2008). Both scales have been used in many studies with patients with psychosis. We used the total scores.

2.3.3. Reasoning: jumping to conclusions—probabilistic reasoning task
Two computerized versions of the probabilistic reasoning (Beads) task, with 85:15 (easy) and 60:40 (difficult) task ratios, were used (Garety et al., 2005). For example, for the easy version of the task, one jar had 85 orange beads and 15 black beads and the other jar had 15 orange beads and 85 black beads. Participants were shown pictures of the two jars and told that one of the jars would be selected at random by the computer and that beads would be drawn from and replaced in the selected jar. After each bead was drawn, participants were asked if they would like to see more beads (i.e., if they would like more information) or if they could say, with certainty, from which of the jars the beads were being drawn. Once a bead had been drawn, it was shown at the bottom of the screen, thereby providing a memory aid. The key variable was the number of beads requested by the participant before making a decision (draws to decision). Jumping to conclusions (JTC) was classified as requesting two or fewer beads.

2.3.4. Neuropsychological tests: Weschler Test of Adult Reading (WTAR), Rey Auditory Verbal Learning Task (RAVLT); and WAIS III subtests: (Digit Span, Digit Symbol, Letter–Number Sequencing)
Premorbid IQ was estimated using the Weschler Test of Adult Reading (WTAR; Wechsler, 2001). Verbal learning was measured using the Rey Auditory Verbal Learning Task (RAVLT; Lezak, 2004) in which participants are read out a list of 15 nouns, repeated 5 times, and asked to recall as many as possible immediately after each list. The verbal learning score is the sum of the words recalled on each of the 5 trials. Processing speed was measured using the Digit Symbol Coding subtest of the WAIS III

(Wechsler, 1997). Participants are shown a key in which numbers 1–9 are each associated with a geometric symbol; they are then given a series of numbers and asked to copy the corresponding symbol under each one. The number of correct number–symbol pairs completed in 120 s is the processing speed score. Working memory was assessed with two sub-tests of WAIS III. In the Digit Span test participants are read a series of numbers and asked to repeat them in the correct order; the series increases progressively in length until the participant fails. This is then repeated with a different series of numbers but the response is this time requested in reverse order. Digit span forwards, the maximum length of numbers achieved, reflects working memory capacity, whereas digit span backwards, the maximum length of numbers given in reverse, additionally reflects the ability to manipulate items in working memory. Letter–Number Sequencing is a stringent test of working memory manipulation. A series of letters and numbers is read out in a mixed order. The participant is asked to repeat the series but to give the numbers in ascending order first and the letters in alphabetical order next. The score is the list length correctly manipulated.

2.4. Analysis

All analyses were carried out using Stata version 12.1 (StataCorp., 2011). All significant test results are quoted as two-tailed probabilities. Analysis of the data distribution of the neuropsychological test results indicated that skewness and kurtosis were within acceptable limits, and the sample size is large enough to assume normality. T-tests were used to compare neuropsychological test performance and symptom scores between individuals with delusions who did and did not show the jumping to conclusions bias.

3. Results

3.1. Participants

Of the 126 individuals in the final sample, 106 (85%) met OPCRIT criteria for an ICD-10 diagnosis of schizophrenia, a further 10 (8%) for schizoaffective disorder, 7 (5.5%) for delusional disorder and the remaining 1 person for 'other non-organic psychotic disorder.' Their mean age was 41.2 years (SD = 11.3), while their mean length of illness was 15.3 years (SD 10.6). Sixty-four percent of the participants were male, 66% were white and 93% were currently unemployed. Thirteen (11%) were currently unmedicated, while 23 (19.5%) were on low (<200 mg), 28 (24%) on medium (200–400) and 54 (46%) on high (>400 mg) doses of chlorpromazine equivalent anti-psychotic medication. Ninety-two percent ($n = 115$) held persecutory delusions, which co-occurred with a wide variety of other delusion types, most frequently ideas of reference ($n = 74$) and delusions of mind reading ($n = 63$). Of the ten participants without a persecutory belief, the most common delusion types were religious ($n = 4$), reference ($n = 4$) and thought insertion ($n = 3$) or broadcasting ($n = 3$), some in combination. The mean reported level of delusion conviction was high at 80.5%, where 100% represented maximum conviction (SD 24.2). Mean symptom scores were as follows: positive symptoms (SAPS), 8.49 (SD 2.9); negative symptoms (SANS), 8.7 (SD 4.1); depression (BDI), 24.8 (SD 13.3); and anxiety (BAI), 20.8 (SD 12.5).

3.2. Jumping to conclusions and neuropsychological functioning

The mean number of draws to decision for the whole sample on the easy (85:15) version of the task was 4.33 (SD = 4.40) and on the harder (60:40) version, 7.22 (SD = 5.66).

The total sample was divided into those who jumped to conclusions and those who did not on each version of the task (defined as two or fewer draws to decision). Forty-one percent had the JTC bias on the easy and 27% on the hard version. Performance on the test of premorbid

IQ (WTAR) and the neuropsychological tests is shown in Table 1 (JTC 85:15) and Table 2 (JTC 60:40).

There were no differences in premorbid IQ between those who jumped to conclusions and those who did not. When the JTC group was defined by the more difficult (60:40) version of the task, those who jumped to conclusions performed significantly worse (p values <0.05) on tests of working memory (Digit Span total and forwards, and Letter–Number Sequencing) and also at trend level ($p = 0.09$) on Digit Span backwards. Those with the JTC bias on the easy (85:15) version likewise performed more poorly on the tests of working memory (Digit Span total and backwards, and Letter–Number Sequencing), but at trend level ($0.05 < p$ values <0.1). Both JTC (easy and hard) groups showed poorer performance on the Rey test of verbal learning and memory (RAVLT), but this failed to reach significance ($0.05 < p$ values <0.1). In order to explore whether working memory contributed to the (non-significant) difference between the groups in performance on this test, we ran a further analysis, in which we controlled for digit span forwards and letter–number sequencing. While there was no evidence for a contribution from digit span forwards, there was an effect of letter–number sequencing. The mean differences were very little changed by adding in digit span forwards as a covariate, and digit span itself was not a significant predictor of RAVLT. However, letter–

Table 1
JTC Beads task 85/15, neurocognition and symptoms.

Measure JTC 85/15	JTC No n (%) 74 (58.7%)	JTC Yes n (%) 52 (41.3%)	Difference		
	Mean (SD)	Mean (SD)	Mean (SE)	Effect size	P-value
RAVLT	38.72 (11.17)	35.35 (10.65)	3.38 (1.98)	0.305	0.0918
Estimated Premorbid IQ (WTAR)	94.55 (14.22)	95.9 (14.50)	-1.35 (2.63)	0.095	0.6083
Digit symbol coding- raw score	50.97 (14.68)	45.6 (16.42)	5.37 (2.83)	0.345	0.0599
Digit span – total raw score	16.38 (4.23)	14.96 (4.22)	1.42 (0.76)	0.332	0.0661
Digit span – raw score (forwards)	10.16 (2.67)	9.42 (2.70)	0.74 (0.48)	0.274	0.1301
Digit span – raw score (backwards)	6.22 (2.11)	5.54 (2.08)	0.68 (0.38)	0.320	0.0766
Letter–number sequencing – raw scores	8.56 (2.72)	7.58 (3.12)	0.98 (0.52)	0.337	0.0630
SAPS	8.14 (3.09)	9.00 (2.65)	-0.86 (0.53)	0.294	0.1062
SAPS – delusions sum	15.86 (0.77)	18.94 (1.13)	-3.08 (1.31)	0.421	0.0208
SAPS – global severity of delusions	1.46 (0.20)	1.43 (0.22)	0.03 (0.30)	0.02	0.9263
SANS	8.95 (3.93)	8.45 (4.27)	0.50 (0.75)	0.122	0.5084
BAI	20.97 (12.76)	20.54 (12.30)	0.43 (2.28)	0.035	0.8494
BDI	23.86 (13.37)	26.10 (13.16)	-2.23 (2.40)	0.168	0.3551

Effect of JTC8515 group on RAVLT when controlling for Digit Span forwards.
Effect of JTC = −3.13, SE = 2.00, p = 0.121, 95% CI = −7.10 to 0.83.
Effect of Digit Span = 0.322, SE = 0.368, p = 0.383, 95% CI = −0.41 to 1.05.
This is close to the unadjusted mean difference of 3.38 (p = 0.0918) above.
Effect of JTC8515 group on RAVLT when controlling for letter–number sequencing.
Effect of JTC = −1.61, SE = 1.64, p = 0.327, 95% CI = −4.86 to 1.63.
Effect of LN sequencing = 1.41, SE = 0.28, p < 0.001, 95% CI = 0.86–1.95).
Since LN sequencing is significant, it has an impact on the effect of JTC of reducing the mean difference.
JTC, jumping to conclusions; RAVLT, Rey Auditory Verbal Learning Test; WTAR, Wechsler Test of Adult Reading; SAPS, Scale for the Assessment of Positive Symptoms; SANS, Scale for the Assessment of Negative Symptoms; BAI, Beck Anxiety Inventory; BDI, Beck Depression Index; SD, standard deviation; SE, standard error.

Table 2
JTC Beads task 60/40, neurocognition and symptoms.

Measure JTC 60/40	JTC No, n (%) 92 (73.0%) Mean (SD)	JTC Yes, n (%) 34 (27.0%) Mean (SD)	Difference Mean (SE)	Effect size	p value
RAVLT	38.47 (10.58)	34.24 (11.83)	4.23 (2.19)	0.383	0.0559
Estimated Premorbid IQ (WTAR)	94.67 (14.26)	96.27 (14.54)	−1.61 (2.92)	0.112	0.5829
Digit symbol coding, raw score	49.10 (15.22)	47.91 (16.75)	1.19 (3.21)	0.077	0.7111
Digit span—total raw score	16.28 (4.23)	14.47 (4.12)	1.81 (0.84)	0.425	0.0337[†]
Digit span—raw score (forwards)	10.15 (2.68)	9.06 (2.62)	1.09 (0.53)	0.406	0.0427[†]
Digit span—raw score (backwards)	6.13 (2.11)	5.41 (2.08)	0.72 (0.42)	0.340	0.0906
Letter–number sequencing—raw scores	8.56 (2.93)	7.06 (2.65)	1.50 (0.57)	0.514	0.0100[†]
SAPS	8.26 (2.90)	9.12 (3.01)	−0.86 (0.59)	0.293	0.1499
SAPS—delusions sum	16.71 (0.68)	18.18 (1.59)	−1.46 (1.48)	0.200	0.3248
SAPS—global severity of delusions	1.43 (0.17)	1.48 (0.29)	−0.05 (0.34)	0.03	0.8824
SANS	8.84 (4.07)	8.48 (4.08)	0.36 (0.83)	0.089	0.6651
BAI	21.29 (13.35)	19.47 (10.03)	1.82 (2.52)	0.145	0.4730
BDI	24.20 (13.45)	26.38 (12.87)	−2.19 (2.67)	0.165	0.4140

Effect of JTC6040 group on RAVLT when controlling for Digit Span forwards.
Effect of = −3.92, SE = 2.23, $p = 0.081$, 95% CI = (−8.34, 0.50).
Effect of Digit Span = 0.283, SE = 0.369, $p = 0.446$, 95% CI = (−0.45, 1.01).
This is close to the unadjusted mean difference of 4.23 ($p = 0.0559$) above.
Effect of JTC6040 group on RAVLT when controlling for letter-number sequencing.
Effect of JTC = −1.44 SE = 1.77, $p = 0.416$, 95% CI = (−4.94, 2.05).
Effect of letter numbering sequencing = 1.40, SE = 0.28, $p < 0.001$, 95% CI = (0.84, 1.96).
Since Letter Number sequencing is significant, it has an impact on the effect of JTC of reducing the mean difference.
JTC, jumping to conclusions; RAVLT, Rey Auditory Verbal Learning Test; WTAR, Wechsler Test of Adult Reading; SAPS, Scale for the Assessment of Positive Symptoms; SANS, Scale for the Assessment of Negative Symptoms; BAI, Beck Anxiety Inventory; BDI, Beck Depression Index; SD, standard deviation; SE, standard error.
[†] $p < 0.05$.

number sequencing had an impact, reducing the effect of JTC on the mean differences and significantly predicting RAVLT (see Tables 1 and 2). A check on whether JTC performance differed by current level of medication (none, low, medium or high dosage) found no differences on either version of the task. Finally, whatever the version of the task, there were no differences between those who jumped to conclusions and those who did not in total positive and negative psychotic symptom scores (SAPS and SANS), in the SAPS global severity of delusions rating or in depression or anxiety (BDI and BAI) (see Tables 1 and 2). However, those who jumped to conclusions on the 85:15 version, but not the 60:40 version, scored significantly more highly than those who did not on a sum of all SAPS delusions items (see Tables 1 and 2).

4. Discussion

We set out to examine the association of jumping to conclusions and working memory in the largest sample of individuals with high conviction delusions tested on these measures to date. The performance of the JTC groups was worse on the majority of tests of working memory than that of their non-JTC counterparts, although this was only significant when JTC group membership was determined from the more difficult version of the task, which has higher working memory processing demands. Patients in the JTC group were more impaired in the ability to

hold information transiently on line and even more so, when performing complex manipulation of information by reordering it while it is maintained in memory. The effect sizes are generally small to medium (see Tables 1 and 2). The groups allocated using the JTC hard version were well matched for other prominent indicators of cognitive dysfunction in schizophrenia—premorbid IQ and processing speed. Verbal learning is also commonly impaired in schizophrenia, and there was a non-significant trend for the JTC group to be worse on this measure. Further analysis revealed that this was accounted for by working memory manipulation (letter–number sequencing) but not working memory span (digit span forwards). This finding is consistent with the known importance of executive processes in optimising memory encoding (Fletcher and Henson, 2001) and previously shown to be impaired in the RAVLT in schizophrenia (Leeson et al., 2009). The pattern of neuropsychological test results and the absence of a significant difference in premorbid IQ supports the hypothesis that JTC is associated with a specific working memory deficit.

How can these findings of an association of neuropsychological impairment with a delusion-related process (JTC) be reconciled with previous studies, including large well-conducted meta-analyses and systematic reviews, showing no association between cognitive impairment and the positive symptoms of psychosis (e.g., de Gracia Dominguez et al., 2009; Ventura et al., 2009)? Note that, unlike many studies, this is a sample selected for the presence of delusions held with high conviction. We propose that these neuropsychological impairments are involved in the formation of delusions, through their contribution to a jumping to conclusions bias. The hypothesised mediating role of JTC, combined with the relatively subtle neuropsychological impairments involved, may go some way to explaining the hitherto limited evidence for neuropsychological impairments in relation to delusions. Bentall et al. (2009), likewise adopting a single symptom approach, found an association of delusional thinking with cognition, specifically on measures of JTC and working memory. The association with working memory is also consistent with that reported by Broome et al. (2007).

One purpose of this study is to inform attempts to develop effective non-pharmacological treatments for delusions, such as recent reasoning training interventions (Moritz et al., 2011; Ross et al., 2011; Waller et al., 2011). One of its implications is that such interventions might benefit from incorporating explicit strategies to compensate for any deficits and to enhance working memory. The interventions could be designed explicitly to reduce working memory load, for example by employing repetition/over-learning of key messages, simplified language and memory prompts. These might also draw on cognitive remediation methods, especially those which promote strategy coaching (McGurk et al., 2007). However they would be specifically targeted at awareness of a tendency to employ minimal cognitive resources, and at using strategies to compensate for this, enhancing data gathering and the evaluation of delusion-related evidence, for example, keeping disconfirmatory evidence for persecutory fears in mind.

Our sample was a selected group of people with delusions held with high conviction and relatively long-standing illnesses. Over 90% had persecutory delusions. This study was not designed to test associations of data gathering with delusions, since the presence of delusions was universal. In this sample, global severity of delusions did not differ in those who did and did not jump to conclusions, though there were indications that those who showed the JTC bias had a higher total number of delusions than those who did not. Research with samples drawn from different stages of illness, including at risk, early and treatment resistant groups and with a greater range in symptomatology, including those with and without delusions, and with different delusion subtypes, is required to replicate and extend these findings. Future research should aim to elucidate the complex relationships between data gathering, working memory and delusions in psychosis. Greater clarity about the neuropsychological impairments associated with the JTC bias should also pave the way for theoretically grounded studies investigating

neurobiological mechanisms of JTC, for example, using neuroimaging (e.g., Broome et al., 2007).

References

Andreasen, N.C., 1984a. Scale for the Assessment of Positive Symptoms (SAPS). University of Iowa, Iowa City, IA.

Andreasen, N.C., 1984b. Scale for the Assessment of Negative Symptoms (SANS). University of Iowa, Iowa City, IA.

Baddeley, A.D., 2000. Short-term and working memory. In: Tulving, E., Craik, F.I.M. (Eds.), The Oxford Handbook of Memory. Oxford University Press, New York, pp. 77–92.

Beck, A.T., Rector, N.A., 2005. Cognitive approaches to schizophrenia: theory and therapy. Annu. Rev. Clin. Psychol. 1, 577–606.

Beck, A.T., Steer, R.A., Brown, G.K., 1996. BDI-II Manual. The Psychological Corporation. Psychological Corporation, San Antonio, Texas.

Beck, A.T., Epstein, N., Brown, G., Steer, R.A., 2008. An inventory for measuring clinical anxiety: psychometric properties. J. Consult. Clin. Psychol. 56, 893–897.

Bentall, R.P., Corcoran, R., Howard, R., Blackwood, N., Kinderman, P., 2001. Persecutory delusions: a review and theoretical interpretation. Clin. Psychol. Rev. 21, 1143–1192.

Bentall, R.P., Rowse, G., Shryane, N., Kinderman, P., Howard, R., Blackwood, N., Moore, R., Corcoran, R., 2009. The cognitive and affective structure of paranoid delusions: a transdiagnostic investigation of patients with schizophrenia spectrum disorders and depression. Arch. Gen. Psychiatry 66, 236–247.

Broome, M., Johns, L.C., Valli, I., Woolley, J.B., Tabraham, P., Brett, C., Valmaggia, L., Peters, E., Garety, P.A., McGuire, P.K., 2007. Delusion formation and reasoning biases in those at clinical risk for psychosis. Br. J. Psychiatry 191, s38–s42.

Burgess, P.W., Simons, J.S., 2005. Theories of frontal lobe executive function: clinical applications. In: Halligan, P.W., Wade, D.T. (Eds.), Effectiveness of Rehabilitation for Cognitive Deficits. Oxford University Press, New York, NY, pp. 211–231.

de Gracia Dominguez, M., Viechtbauer, W., Simons, C.J.P., van Os, J., Krabbendam, L., 2009. Are psychotic psychopathology and neurocognition orthogonal? A systematic review of their associations. Psychol. Bull. 135, 157–171.

Dudley, R.E., John, C.H., Young, A.W., Over, D.E., 1997. Normal and abnormal reasoning in people with delusions. Br. J. Clin. Psychol. 36, 243–258.

Dudley, R., Daley, K., Nicholson, M., Shaftoe, D., Spencer, H., Cavanagh, K., Freeston, M., 2013. Jumping to conclusions' in first-episode psychosis: a longitudinal study. Br. J. Clin. Psychol. (in press).

Fine, C., Gardner, M., Craigie, J., Gold, I., 2007. Hopping, skipping or jumping to conclusions? Clarifying the role of the JTC bias in delusions. Cogn. Neuropsychiatry 1, 46–77.

Fletcher, P.C., Henson, R.N., 2001. Frontal lobes and human memory: insights from functional neuroimaging. Brain 124, 849–881.

Freeman, D., 2007. Suspicious Minds: the psychology of persecutory delusions. Clin. Psychol. Rev. 4, 425–457.

Freeman, D., Garety, P.A., Kuipers, E., Fowler, D., Bebbington, P., 2002. A cognitive model of persecutory delusions. Br. J. Clin. Psychol. 41, 331–347.

Garety, P.A., Freeman, D., 2013. The past and future of delusions research: from the inexplicable to the treatable. Br. J. Psychiatry (in press).

Garety, P.A., Hemsley, D.R., Wessely, S., 1991. Reasoning in deluded schizophrenic and paranoid patients: biases in performance on a probabilistic inference task. J. Nerv. Ment. Dis. 179, 194–201.

Garety, P.A., Freeman, D., Jolley, S., Dunn, G., Bebbington, P.E., Fowler, D.G., Kuipers, E., Dudley, R., 2005. Reasoning, emotions and delusional conviction in psychosis. J. Abnorm. Psychol. 114, 373–384.

Garety, P., Bebbington, P., Fowler, D., Freeman, D., Kuipers, E., 2007. Implications for neurobiological research of cognitive models of psychosis: a theoretical paper. Psychol. Med. 37, 1377–1391.

Green, M.F., 1996. What are the functional consequences of neurocognitive deficits in schizophrenia? Am. J. Psychiatry 153 (3), 321–330.

Horan, W.P., Braff, D.L., Nuechterlein, K.H., Sugar, C.A., Cadenhead, K.S., Calkins, M.E., Dobie, D.J., Freedman, R., Greenwood, T.A., Gur, R.E., Gur, R.C., Light, G.A., Mintz, J., Olincy, A., Radant, A.D., Schork, N.J., Seidman, L.J., Siever, L.J., Silverman, J.M., Stone, W.S., Swerdlow, N.R., Tsuang, D.W., Tsuang, M.T., Turetsky, B.I., Green, M.F., 2008. Verbal working memory impairments in individuals with schizophrenia and their first-degree relatives: findings from the Consortium on the Genetics of Schizophrenia. Schizophr. Res. 103, 218–228.

Kapur, S., 2003. Psychosis as a state of aberrant salience: a framework linking biology, phenomenology, and pharmacology in schizophrenia. Am. J. Psychiatry 160, 13–23.

Langdon, R., Ward, P.B., Coltheart, M., 2008. Reasoning anomalies associated with delusions in schizophrenia. Schizophr. Bull. 36 (2), 321–330.

Leeson, V.C., Robbins, T.W., Franklin, C., Harrison, M., Harrison, I., Ron, M.A., Barnes, T.R., Joyce, E.M., 2009. Dissociation of long-term verbal memory and fronto-executive impairment in first-episode psychosis. Psychol. Med. 39, 1799–1808.

Lezak, M.D., 2004. Neuropsychological Assessment. Oxford University Press, New York, NY.

Lincoln, T.M., Lange, J., Burau, J., Exner, C., Moritz, S., 2010. The effect of state anxiety on paranoid ideation and jumping to conclusions. An experimental investigation. Schizophr. Bull. 36, 1140–1148.

Lunt, L., Bramham, J., Morris, R.G., Bullock, P.R., Selway, R.P., Xenitidis, K., David, A.S., 2012. Prefrontal cortex dysfunction and 'jumping to conclusions': bias or deficit? J. Neuropsychol. 6, 65–78.

McGurk, S.R., Twamley, E.W., Sitzer, D.I., McHugo, G.J., Mueser, K.T., 2007. A meta-analysis of cognitive remediation in schizophrenia. Am. J. Psychiatry 164, 1791–1802.

McKay, R., Langdon, R., Coltheart, M., 2007. Jumping to delusions? Paranoia, probabilistic reasoning, and need for closure. Cogn. Neuropsychiatry 12, 362–376.

Menon, M., Mizrahi, R., Kapur, S., 2008. 'Jumping to conclusions' and delusions in psychosis: relationship and response to treatment. Schizophr. Res. 98, 225–231.

Merrin, J., Kinderman, P., Bentall, R.P., 2007. Jumping to conclusions and attributional style in patients with persecutory delusions. Cogn. Ther. Res. 31, 741–758.

Moritz, S., Woodward, T.S., 2005. Jumping to conclusions in delusional and non delusional schizophrenic patients. Br. J. Clin. Psychol. 44, 193–207.

Moritz, S., Woodward, T.S., 2007. Metacognitive training in schizophrenia: from basic research to knowledge translation and intervention. Curr. Opin. Psychiatry 20, 619–625.

Moritz, S., Woodward, T.S., Lambert, M., 2007. Under what circumstances do patients with schizophrenia jump to conclusions? a liberal acceptance account. Br. J. Clin. Pyschol. 46, 127–137.

Moritz, S., Vitzthum, F., Randjbar, S., Veckenstedt, R., Woodward, T.S., 2010. Detecting and defusing cognitive traps: Metacognitive intervention in schizophrenia. Curr. Opin. Psychiatry 23, 561–569.

Moritz, S., Kerstan, A., Veckenstedt, R., Randjbar, S., Vitzthum, F., Schmidt, C., Heise, M., Woodward, T.S., 2011. Further evidence for the efficacy of metacognitive group training in schizophrenia. Behav. Res. Ther. 49, 151–157.

Ormrod, J., Shaftoe, D., Cavanagh, K., Freeston, M., Turkington, D., Price, J., Dudley, R., 2012. A Pilot Study Exploring the Contribution of Working Memory to 'jumping to conclusions' in People with First Episode Psychosis. Cogn. Neuropsychiatry 17 (2), 97–114.

Peters, E., Garety, P.A., 2006. Cognitive functioning in delusions: a longitudinal examination. Behav. Res. Ther. 44, 481–514.

Peters, E.R., Thornton, P., Siksou, L., Linney, Y., MacCabe, J.H., 2008. Specificity of the 'jump-to-conclusions' bias in deluded patients. Br. J. Clin. Psychol. 47, 239–244.

Rector, N.A., Beck, A.T., 2001. Cognitive behavioural therapy for schizophrenia: an empirical review. J. Nerv. Ment. Dis. 189, 278–287.

Ross, K., Freeman, D., Dunn, G., Garety, P., 2011. A Randomized Experimental Investigation of Reasoning Training for People With Delusions. Schizophr. Bull. 37, 324–333.

So, S.H., Freeman, D., Garety, P., 2008. Impact of state anxiety on the jumping to conclusions delusion bias. Aust. N. Z. J. Psychiatry 42, 879–886.

So, S.H., Freeman, D., Dunn, G., Kapur, S., Kuipers, E., Bebbington, P., Fowler, D., Garety, P.A., 2012. Jumping to conclusions, a lack of belief flexibility and delusional conviction in psychosis: a longitudinal investigation of the structure, frequency, and relatedness of reasoning biases. J. Abnorm. Psychol. 121, 129–139.

StataCorp, 2011. Stata Statistical Software: Release 12. StataCorp LP, College Station, TX.

van Dael, F., Versmissen, D., Janssen, I., Myen-Germeys, I., van Os, J., Krabbendam, L, 2006. Data Gathering: Biased in Psychosis? Schizophr. Bull. 32, 341–351.

van der Gaag, M., 2006. A neuropsychiatric model of biological and psychological processes in the remission of delusions and auditory hallucinations. Schizophr. Bull. 32, s113–s122.

van Hooren, S., Versmissen, D., Janssen, I., Myin-Germeys, I., a Campo, J., Mengelers, R., van Os, J., Krabbendam, L., 2008. Social cognition and neurocognition as independent domains in psychosis. Schizophr. Res. 103, 257–265.

Ventura, J., Hellemann, G.S., Thames, A.D., Koellner, V., Nuechterlein, K.H., 2009. Symptoms as mediators of the relationship between neurocognition and functional outcome in schizophrenia: a meta-analysis. Schizophr. Res. 113, 189–199.

Waller, H., Freeman, D., Jolley, S., Dunn, G., Garety, P., 2011. Targeting reasoning biases in delusions: a pilot study of the Maudsley Review Training Programme for individuals with persistent, high conviction delusions. J. Behav. Ther. Exp. Psychiatry 42 (3), 414–421.

Wechsler, D., 1997. WAIS III Wechsler Adult Intelligence Scale, Third edition. Psychological Corporation, San Antonio, Texas.

Wechsler, D., 2001. Wechsler Test of Adult Reading. Psychological Corporation, London.

Woodward, T.S., Mizrahi, R., Menon, M., Christensen, B.K., 2008. Correspondences between theory of mind, jumping to conclusions, neuropsychological measures and the symptoms of schizophrenia. Psychiatry Res. 170, 119–123.

Young, H.F., Bentall, R.P., 1995. Hypothesis testing in patients with persecutory delusions: comparison with depressed and normal subjects. Br. J. Clin. Psychol. 34, 353–369.