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Patterns of evidence integration in schizophrenia and delusion

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ABSTRACT

Previous studies documented a bias against disconfirmatory evidence (BADE) in patients affected by schizophrenia spectrum disorders, with some discrepant findings on its relationship with delusions. In order to further investigate the patterns of evidence integration in schizophrenia and delusion, we recruited 40 deluded and non-deluded patients with schizophrenia and 40 healthy control subjects. Participants were administered the BADE test, which consisted of 30 delusion-neutral scenarios, each one progressively described by three subsequent disambiguating statements and providing four types of interpretation to rate for plausibility; at every additional evidence presentation, participants were asked to adjust their ratings. In contrast to previous works, patients displayed both a BADE and a bias against confirmatory evidence (BACE) relative to healthy subjects, as they reduced plausibility ratings on incorrect interpretations and increased plausibility ratings on correct interpretation significantly less over trial progress. Moreover, BACE and BADE measures showed to discriminate differentially control from schizophrenia participants and delusional from non-delusional patients.

1. Introduction

Current cognitive models of psychosis propose multidimensional accounts for delusions formation, development and maintenance which try to integrate several interacting but independent factors: anomalies in perception, motivation, affect and cognition, meta-representation and beliefs system have been recognized to have a predisposing or precipitating role in delusion.

For example, Bentall and colleagues first showed the relation between a global, stable and externalizing attributional style (Kaney and Bentall, 1989) and delusions, as well as Frith explained persecutory and referential delusions as based upon a ToM (theory of mind) deficit, an impairment in inferring others' thoughts and intentions (Frith and Corcoran, 1996). Other models implicate emotion related processes: in the "threat anticipation model" paranoid patients overestimate the likelihood of threatening events (Kaney et al., 1997).

While attributional and ToM account of psychosis focuses on specific delusional themes, theorizing about reasoning deficits applies to all kinds of delusions; this distinction is of some concern in studies on schizophrenia, where many and different kinds of false beliefs are labeled as delusions (Frith, 1999; Langdon et al., 2010).

As to reasoning processes, in their pioneering work Garety and colleagues inscribed their account for delusion in the framework of Bayesian inference, predicting that in a probability judgment task "people with delusions would make more rapid and over-confident judgments than other clinical and non-clinical controls" (Garety and Freeman, 1999).

This reasoning style, characterized by the tendency toward early acceptance of hypotheses, has been consistently replicated in schizophrenia with the paradigmatic Beads task, in which it translates into "less draws to decision" (but not less "draws to certainty") and takes the name of Jumping To Conclusions bias (JTC). Rather than a general deficit in probabilistic reasoning, JTC has been described as a data-gathering bias that contributes to the lack of belief flexibility leading, in turn, to persistent delusional conviction and lower change potential (Garety et al., 2005). Patients seek less information to reach a decision rather than differ in certainty, that is to say they need less subjective probability to come to a conclusion.

Moritz, Woodward and co-workers set up a liberal acceptance (LA) account for JTC in schizophrenia, hypothesizing that patients rest their decisions on little evidence because of a lowered decision threshold. Using a paradigm that resembles the "who wants to be a millionaire" show (Moritz et al., 2006) and a

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paintings-to-title task (Moritz et al., 2009), in addition to a variant of the classic Beads task (Moritz et al., 2007), they proved that individuals with schizophrenia base decisions on lower subjective likelihood than controls. Importantly, in LA account, requiring less evidence to accept options does not necessarily implies a JTC (Moritz et al., 2007), which is expected when there are few alternatives mutually exclusive and one option stands out among others (low ambiguity). With more and less distinct alternatives (high ambiguity) LA account predicts a delay in taking a decision, since more options are considered.

The results of a recent meta-analysis (Fine et al., 2007) support a difference in the amount of evidence collected from deluded patients to reach a decision and confirm an hypothesis, difference which cannot be considered an epiphenomenon of schizophrenia. Their findings also suggest that when dealing with conflicting evidence, patients do not seem to "jump to new conclusion". Two issues remained unsolved: (1) JTC paradigms failed to sort out how patients treat contradictory information once a belief has been accepted (that is to say: why delusion persists in the face of disconfirmatory evidence?); (2) JTC bias facilitates the hasty acceptance of the (delusional) hypothesis but a delusional thought must be present before JTC affects its development in delusion (that is to say: before investigation of confirmatory and disconfirmatory evidence, an hypothesis must be judged worthy of consideration; why patients consider seriously implausible hypotheses?).

Woodward et al. (2006b) introduced a new neuropsychological paradigm, aimed to investigate the possibility of a failure in integrating disconfirmatory evidence (bias against disconfirmatory evidence—BADE): if delusions are based on a confirmatory reasoning style, which discards disconfirmatory evidence, JTC could enlighten the mechanism of the former and BADE of the latter (*issue* 1). Furthermore, the BADE task was designed to allow exploration of LA of implausible interpretations also (*issue* 2).

In these studies, participants are presented with delusion-neutral sequences of pictures (Woodward et al., 2006b; Moritz and Woodward, 2006) or sentences (Woodward et al., 2007, 2008; Moritz et al., 2010) that progressively disambiguate a scenario, adding confirmatory or disconfirmatory evidence; for each scenario, different interpretations are provided to rate for plausibility and at every additional evidence presentation subjects are asked to adjust their ratings.

In the sentences version of the task, the interpretations have been designed to elicit different patterns of ratings across three informational levels and every scenario is presented with four types of possible interpretations: one true (initially not much plausible, becomes increasingly the most plausible), two lures (initially more plausible of the true, across levels become implausible; two variants: neutral lure and emotional lure) and one absurd (implausible at all stages).

For example, the first informational level of a scenario is represented by the statement "Jenny can't fall asleep". Interpretations given to rate for plausibility are: "Jenny is nervous about her exam the next day" (neutral lure), "Jenny is worried about her ill mother" (emotional lure), "Jenny is excited about Christmas morning" (true) and "Jenny loves her bed" (absurd). At the successive two stages of the trial a second and a third informative sentences are added: respectively, "Jenny can't wait until it is finally morning" and "Jenny wonders how many presents she will find under the tree". After each additional presentation, plausibility of each interpretation should be updated considering all evidence.

In Moritz, Woodward and co-authors works, the progressive upgrading and experimental manipulation of BADE paradigm from first to later researches makes quite hard the comparison between studies.

Time by time, the BADE task has been varied in stimuli (visual vs. verbal), ratings scale (Likert-type vs. continuous), nominal categories, number of trials, stages and interpretations, outcomes computation for bias indexes and indexes considered, analyses performed, assessment scale and criterion to discriminate deluded subjects from not deluded subjects; these changes could account for the discrepancies in findings obtained in different studies.

Therefore, we consider here for clarity only later works which made use of verbal stimuli although previous researches also provided evidence for a BADE, particularly accentuated in deluded patients, and a LA bias in schizophrenia (Moritz and Woodward, 2004; Woodward et al., 2006b; Moritz et al., 2006).

A study on a sample of first episode schizophrenia spectrum disorders vs. healthy controls (Woodward et al., 2006a), with 2 interpretations (true and lure) to rate, unspecified number of scenarios and 3 descriptions for each, showed a difference in BADE (computed as the decrease from sentence 1 to 3 in lure ratings) between controls and patients and, among these, between acutely delusional (4 or higher score on Positive and Negative Syndrome Scale (PANSS) delusion and paranoid ideation items) and non-delusional groups; no difference in BACE (first-to-third increase of plausibility in true ratings) was found.

In an exploratory principal component analysis (Woodward et al., 2007) a version of the test consisting in 30 scenarios with four interpretations and three levels, administered to a sample of schizotypal students, was employed. The BADE measures submitted to the factor analysis were all plausibility ratings for neutral and emotional lures; two independent factor emerged: Initial Belief (composed primarily of ratings at level 1 and partly of ratings at level 2) and Integration of Disconfirmatory Evidence (partly ratings after sentence 2 and primarily after 3). None of the six considered measures of BADE correlated with neuropsychological variables and Integration of Disconfirmatory Evidence was the only factor that correlated with delusional ideation.

The following research recruited patients with schizophrenia or schizoaffective disorders, obsessive-compulsive disorder and healthy controls (Woodward et al., 2008); the BADE task included 20 experimental and five filler scenarios, with some trial adapted from a prior version (2006b) and others newly developed. Scenarios were classified, by lure strength, in weak and strong, using ratings for true and lure interpretations provided by healthy subjects at the first sentence presentation. The dependent variables computed to index BADE and BACE were the means of ratings at sentence 2 and 3 subtracted from ratings at first for, respectively, lure and true items; the same was made for absurd items, even if a floor effect was expected. Score changes were covariated for initial plausibility ratings. In contrast with previous studies, analyses did not find differences in performance between delusional (three or higher score on PANSS delusion item) and non-delusional groups whereas, when pooled together, schizophrenia patients showed a BADE only in the strong lure condition. Schizophrenia vs. mixed-controls analysis revealed no BACE nor LA bias.

A second principal component analysis (Moritz et al., 2010) investigated the intercorrelations of cognitive biases, motivational factors, neuropsychological and psychopathological measures. Current version of the task implicated 24 scenarios with four interpretations and BADE index was the variable of interest, computed as ratings change for lures from sentence 1 to 3. Four independent components were identified among these "inflexibility" (BADE and need for closure). BADE correlated with pre-morbid intelligence but correlational analysis found no relation between inflexibility and neuropsychological or psychopathological variables.

The last research analyzing the relationship between the BADE and delusional ideation (Veckenstedt et al., 2011) compared patients with schizophrenia or schizoaffective disorder, OCD and healthy controls on a task containing 16 experimental and eight control scenarios with four interpretations: 2 lures, 1 absurd and 1 true (here defined as interpretation frequently judged as less plausible than lures after the first statement). Again, BADE and BACE were calculated with score changes for lure and true interpretations from sentence 1 to 3; LA index was computed as decision threshold (minimum plausibility rating underlying a decision). A trend difference emerged between deluded (three or higher score either on delusion or suspiciousness PANSS items) and nondeluded patients in BACE. Schizophrenia patients rated significantly less plausible the true interpretations and more plausible the lures than both psychiatric and non-psychiatric controls and this difference was attributed to the BADE rather than BACE. Lastly, no significant correlations were found with core positive items.

The aim of the present study was to explore with the BADE task the patterns of integration of confirmatory and disconfirmatory evidence in schizophrenia patients, with and without delusions, compared to healthy controls. We used the version of the task with more scenarios ($n=30$) and performed exhaustive analyses on all computable outcomes. We expected to replicate and clarify previous literature findings, in particular the differences in the pattern of integration of information (significant interactions type × levels), independent from the emotional salience of the context (no differences between neutral and emotional lures). As to absurd condition, we also pursued the hypothesis that the possible emergence of a LA bias related to absurd interpretations of provided scenarios could account for the *qualitative* aspect of delusional thought acceptance rather than *quantitative* as in JTC. That is to say, we expected patients to rate absurd options more plausible than controls. Furthermore, we evaluated correlations between cognitive biases and cognitive functioning, symptomatology, metacognition.

2. Methods

2.1. Subjects

Forty clinically stabilized patients, all meeting DSM IV criteria for schizophrenia as determined by trained psychiatrists, were recruited from the Department of Clinical Neurosciences, San Raffaele Hospital, Milan. Exclusion criteria were substance dependence or abuse, co-morbid diagnosis on Axis I or II, major neurological illness, perinatal trauma and mental retardation.

Forty healthy controls, recruited from hospital staff and general population, participated in the study and were screened to exclude history of neurological illness, psychiatric disorders and substance abuse.

Written informed consent was obtained from all subjects, the study complies with the principles of the Declaration of Helsinki.

2.2. Measures

Psychopathology was assessed by means of PANSS (Kay et al., 1987), administered by trained psychiatrists.

Neurocognitive deficits were evaluated with the Italian version (Anselmetti et al., 2008) of BACS (Brief Assessment of Cognition in Schizophrenia, Keefe et al., 2004), which includes words recall (verbal memory), digits sequencing (working memory), token motor task (psychomotor speed and coordination), symbol coding (selective attention), semantic and phonemic fluency (verbal fluency) and Tower of London (ToL; executive functions).

Patients were also administered the Wisconsin Card Sorting Test (WCST; Stratta et al., 1997) and Continuous Performance Test (CPT; Stratta et al., 2004).

ToM was assessed using the Theory of Mind Picture Sequencing Task (BPST; Brune, 2003); the variable of interest of this study was the total scores at the Questionnaire.

Evidence integration and confirmatory/disconfirmatory biases were measured with the BADE test (Woodward et al., 2007) which consists of 30 scenarios, each one progressively described by three successive disambiguating statements (informational levels) and providing four types of interpretation (lure, emotional lure, absurd and true answers) to rate for plausibility. At every additional information presentation, participants were asked to adjust their judgments. Plausibility was rated on a continuous scale (0–10 scrollbar) with nominal cues (poor, possible, good, excellent). Increasing and decreasing ratings were then computed to calculate indexes of BADE, BACE and LA bias.

Precise instructions follow: “You will see 4 sentences on a screen and each sentence will have its own scroll bar or scale. I would like you to use these scroll bars to rate the plausibility of each sentence after you have been given a specific hint (shown at the top of the screen). In other words, I would like you rate how well each of the 4 sentences relate to and/or is a good response to the given hints (ratings are on a scale from 0 to 10). The scale has some words to remind you what the 0 to 10 mean; for example the scale ranges from poor sentence to possible sentence to good sentence all the way through to excellent sentence.

Before you start I would like you to be aware that you will be given 3 hints in total and each hint gives you a little more information than the previous one, to create a mini story. With each hi9nt you will be asked to change your ratings as you are given more information. You may change your mind or score for each sentence as little or as muchas you like and one or more of the ratings can be the same if you feel that they have equal plausibility. Or you may even feel that you would like to keep some of the ratings the way they were even after being given an additional hint.

But please note that each of the 4 sentences should be rated independently from one another. In other words, don’t compare the 4 sentences to one another; instead rate how well they relate to the hints on their own. It is possible that none or many of the sentences would provide a good fit to the hint.”

2.3. Strategy of data analysis

Demographic characteristics of the sample were analyzed with Chi-Squared test or *t*-test.

To explore differences in mean plausibility ratings between groups we performed a MANOVA 2 (schizophrenia vs. control) × 3 (informational levels) for every types of interpretation: true, neutral lure (NL), emotional lure (EL) and absurd.

In order to examine the patterns of evidence integration, a repeated measures ANOVA with group as between factor (schizophrenia vs. control) and informational level as within factor (first, second and third sentence) was conducted on plausibility ratings, separately for each interpretation.

Then, we computed an index of ratings change over trials for each interpretation type, by averaging plausibility scores given at levels 2 and 3 and subtracting them from those given at level 1 (Woodward et al., 2008). This allowed us to extract 2 indexes of decrease in plausibility following disconfirmatory evidence (from change in NL and EL), 1 index of maintenance of implausible option (absurd) and 1 index of increase in plausibility following confirmatory evidence (true). The sign has been reversed for computation of confirmatory index.

To disentangle the role of schizophrenia diagnosis and presence of delusions on the integration of different kinds of evidence, we entered these outcomes as dependent variables in four one-way ANCOVAs (one for each) with a three levels group factor: healthy controls ($n=40$), not-deluded schizophrenia patients ($n=9$), deluded schizophrenia patients (three or higher score on PANSS delusion item; $n=31$). In order to control for the effect of initial belief, in all analyses rating changes were covariated for ratings at first level (Woodward et al., 2006a, 2008). The correlation between indexes of ratings change and scores on PANSS delusion item was also calculated.

Bonferroni post-hoc test for multiple comparisons correction followed every analysis.

Lastly, we calculated a general BADE index collapsing together mean ratings for interpretations that turned out to be false (NL, EL and absurd); computing procedure was the same as above illustrated (mean scores between second and third levels, subtracted from those of first level). This disconfirmatory index and the confirmatory index provided by score change in true interpretations were then entered in correlational analyses, to explore relationship with neuropsychological and psychopatological measures. We selected a priori some measures to correlate with bias indexes, in order to avoid raising the probability of false-positive findings (scores on BACS working memory, verbal memory, selective attention, ToL tasks; WCST number of perseverative errors; PANSS total, positive, negative and general subscales; BPST Questionnaire). A regression within patients with delusion and rating change scores was also performed.

3. Results

Demographic and clinical characteristics of the sample are listed in Tables 1 and 2; groups did not differ on age ($t(78)=-1.07$, $P=0.29$) and gender ($X=0.80$, $P=0.37$) but controls had significantly higher education than schizophrenia patients ($t(78)=5.78$, $P<0.001$). Deluded patients scored significantly higher than not deluded patients on PANSS total, delusion item,

Table 1
Demographic characteristics of the sample.

	Schizophrenia (n=40)		Healthy (n=40)			
	Mean	**S.D.**	**Mean**	**S.D.**	**T/X^2**	**P**
Age	39.65	10.53	36.83	13.02	−1.07	0.29
Education	12.2	2.34	15.6	2.66	5.78	<0.001*
Sex (males num)	19		24		0.80	0.37

* *significant differences marked.*

Table 2
Clinical characteristics of patients.

	Deluded (n=31)		Non-deluded (n=9)			
	Mean	**S.D.**	**Mean**	**S.D.**	**T**	**P**
Onset	23.26	5.56	22.50	5.53	−0.34	0.74
Illness Duration	16.85	8.21	14.25	8.51	−0.78	0.44
Delusional score	4.29	0.97	1.71	0.49	−6.67	<0.001*
PANSS POS	19.19	5.67	12	4.55	−3.13	<0.005*
PANSS NEG	22.85	5.94	15.71	5.74	−2.88	<0.01*
PANSS GEN	37.13	10.36	30.57	9.48	−1.53	0.13
PANSS TOT	79.16	19.71	58.29	17.34	−2.58	0.01*
WCST	15.54	10.57	8.63	11.26	−1.61	0.12
CPT	31.33	49.45	18.71	30.51	−0.64	0.52
Verbal Memory	42.23	11.89	49.34	11.07	1.60	0.12
Working Memory	16.01	4.19	18.14	6.38	1.19	0.24
Coordination	66.90	22.38	71.00	23.60	0.48	0.64
Fluency	39.95	13.32	50.07	13.07	2.01	0.05
Attention	38.60	14.07	47.54	15.15	1.65	0.11
Executive Function	13.34	3.75	16.26	3.82	2.06	<0.05*
BPST Questionnaire	16.87	4.86	19.22	3.87	1.33	0.19

* *significant differences marked.*

positive and negative subscales and lower on ToL test of esecutive function. A trend level difference was also detected in verbal fluency.

The multivariate group effect on plausibility ratings was significant (Wilks λ=0.39, $F(12.67)=8.86$, $P<0.001$); univariate analyses confirmed an effect of group factor on all dependent variables. Post-hoc analyses showed significant differences between controls and patients at levels 2 and 3 for true interpretation, at level 3 for NL and EL and at every level for absurd condition (see Table 3 and Fig. 1 for complete results).

Repeated measures ANOVAs found a significant main effect of group for True, EL and Absurd condition (True: $F(1.78)=19.77$, $P<0.001$; EL: $F(1.78)=4.88$, $P=0.03$; Absurd: $F(1.78)=17.1$, $P<0.001$) and a significant effect of level (True: $F(2.156)=30.79$, $P<0.001$; NL: $F(2.156)=158.97$, $P<0.001$; EL: $F(2.156)=130.39$, $P<0.001$; Absurd: $F(2.156)=246.88$, $P<0.001$) for all ratings.

As expected, all group × level interactions were significant, indicating different pattern of evidence integration between controls and patients (True: $F(2.156)=6.315$, $P<0.005$; NL: $F(2.156)=22.71$, $P<0.001$; EL: $F(2.156)=18.85$, $P<0.001$; Absurd: $F(2.156)=6.31$, $P<0.005$).

Differences within groups that survived Bonferroni corrections are visualized in Fig. 2.

Across trials, control subjects significantly changed their plausibility ratings from level 1 to level 2 and from level 2 to level 3 for all interpretations (true, NL, EL: $P<0.001$; absurd: $P<0.005$).

Patients' ratings did not differ significantly from the first level to the second in any interpretation type but true ($P<0.001$) but changed significantly from the second to the third in all (true, NL, EL: $P<0.001$; absurd: $P<0.05$).

ANCOVAs on indexes of ratings change resulted in a significant effect of diagnosis for every dependent variable: true ($F(2.76)=15.45$, $P<0.001$), NL ($F(2.76)=14.62$, $P<0.001$), EL ($F(2.76)=15.21$, $P<0.001$) and absurd ($F(2.76)=8.53$, $P<0.001$). Correction for multiple comparisons, as can be derived from Fig. 3, revealed that change in plausibility for the true interpretations differed between controls and schizophrenia patients, irrespective of delusions (control vs. nondelusional: $P=0.003$; control vs delusional: $P=0.001$; nondelusional vs. delusional: ns). In NL and EL there was no significant difference between controls and not-deluded patients but the delusional group decreased ratings significantly less than both healthy ($P<0.001$ and $P<0.001$) and not-deluded ($P<0.003$ and $P<0.001$) subjects. As to absurd interpretations, we found a significant difference between controls and deluded patients ($P=0.003$) and a difference emerged at trend level between nondelusional and delusional group ($P=0.05$).

Correlations between scores on PANSS delusion item and ratings change resulted to be significant for lure interpretations only (NL: $r=-0.45$, $P=0.003$; EL: $r=-0.51$, $P=0.001$; absurd: $r=-0.28$, $P=0.08$. See Fig. 4).

The general disconfirmatory index was significantly correlated with WCST perseverative errors ($r=-0.34$, $P=0.05$), BPST questionnaire score ($r=0.36$, $P=0.04$) and ToL scores at trend level ($r=0.33$, $P=0.06$) and the confirmatory index with verbal memory ($r=-0.37$, $P=0.03$); neither showed a significant correlation with PANSS, WCST and BPST. Regression analysis showed that BADE index is a significant predictor of delusional scores on PANSS scale ($R=0.47$, $P<0.005$).

4. Discussion

Recent psychological literature on schizophrenia has identified some biased reasoning processes which contribute to the development and persistence of delusional conviction (Garety and Bebbington, 2004). These cognitive biases have been applied differentially to belief formation and maintenance, with the hypothesis that faulty appraisal of alternatives could led to the acceptance of delusional explanations. Delusional reasoning style is believed to be mediated by two processes: obtaining confirmatory evidence and discarding disconfirmatory evidence; a failure in integrating disconfirmatory, but not confirmatory, evidence has been documented in schizophrenia spectrum disorders, with discrepant findings on its relationship with delusions.

In the current study we investigated the pattern of evidence integration in a sample of schizophrenia patients relative to healthy controls by means of the BADE task and extended literature findings on the role of reasoning biases in delusion.

Our results confirm differences between control and schizophrenia group in the degree of ratings revision in light of new evidence collection (as significant interactions in repeated measures ANOVAs indicate). In contrast to previous studies by Moritz and co-workers, differences extend to true condition also. Patients displayed both a BADE and a BACE relative to healthy subjects, as they reduced plausibility ratings on incorrect interpretations and increased plausibility ratings on correct interpretation significantly less over trial progress.

At the first presentation of the scenario, when uncertainty is high, judgments did not differ between groups in any type of interpretation but absurd: this suggests to rule out a general probability reasoning deficit among schizophrenic subjects. Moreover a qualitative LA account for belief formation seems to be supported, as patients are more liberal than controls in accepting absurd explanations. At the last stage of the trial (level 3), when

Table 3
MANOVA between groups: differences in plausibility ratings.

	Level 1			Level 2			Level 3		
	Control m/S.D.	**Patients m/S.D.**	***P***	**Control m/S.D.**	**Patients m/S.D.**	***P***	**Control m/S.D.**	**Patients m/S.D.**	***P***
True	4.60/1.86	3.85/2.17	0.10	6.94/1.52	5.20/2.27	< 0.001*	9.55/0.50	7.47/2.52	< 0.001*
Neutral Lure	5.23/1.80	4.43/2.10	0.07	3.27/1.06	3.75/1.84	0.16	0.79/0.69	2.44/2.07	< 0.001*
Emotional Lure	4.08/1.57	3.78/2.07	0.46	2.73/0.71	3.32/1.90	0.07	0.53/0.59	2.20/1.84	< 0.001*
Absurd	0.96/0.63	1.81/1.47	< 0.005*	0.63/0.32	1.81/1.57	< 0.001*	0.31/0.27	1.51/1.57	< 0.001*

* *significant differences corrected for multiple comparisons* (*Bonferroni post-hoc test*).

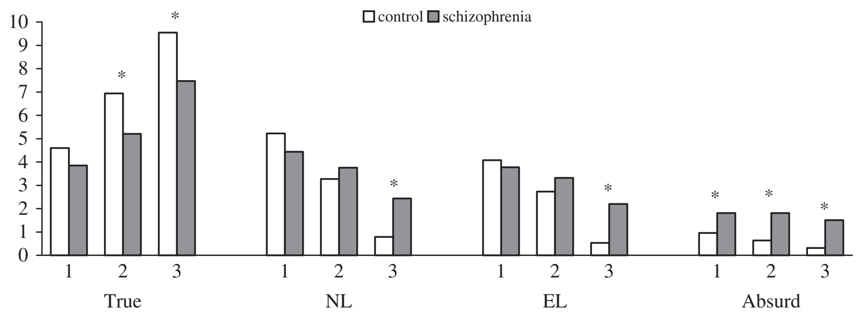

Fig. 1. MANOVA between groups: differences in plausibility ratings. * *significant differences corrected for multiple comparisons* (*Bonferroni post-hoc test*).

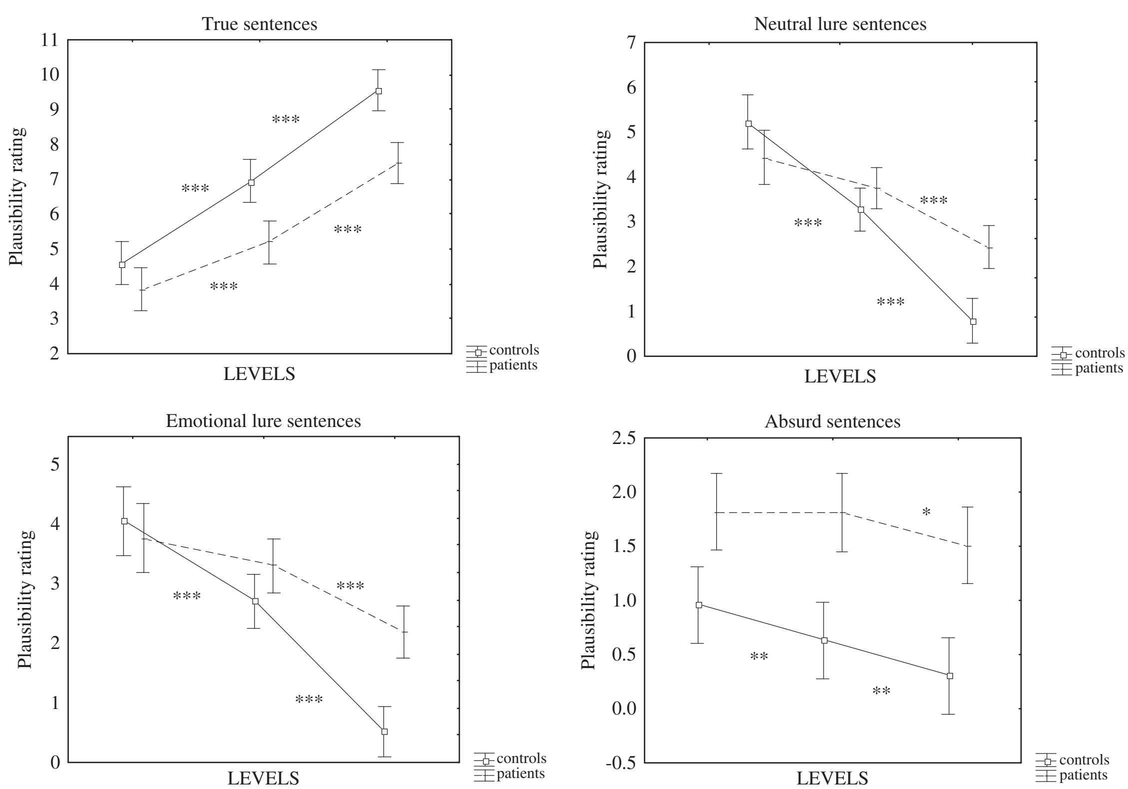

Fig. 2. Repeated Measures ANOVAs: patterns of evidence integration. *Significant differences within groups* (*level* 1 vs. *level* 2 *and level* 2 vs. *level* 3) *marked*: $^{*}=P<0.05$, $^{**}P<0.005$, $^{***}=P<0.001$.

the story depicted by the scenario is completely disambiguated, schizophrenia group's ratings significantly differed from those of controls on every interpretation, strongly suggesting a more conservative strategy of both confirmatory and disconfirmatory evidence integration. As predicted by LA account of psychosis, when ambiguity is high patients do not display a JTC style of response but change their plausibility estimates less quickly than controls, since more options are considered. Patients with schizophrenia seem to display overconfidence in errors and at the same time to be less confident in correct responses. In recent studies on

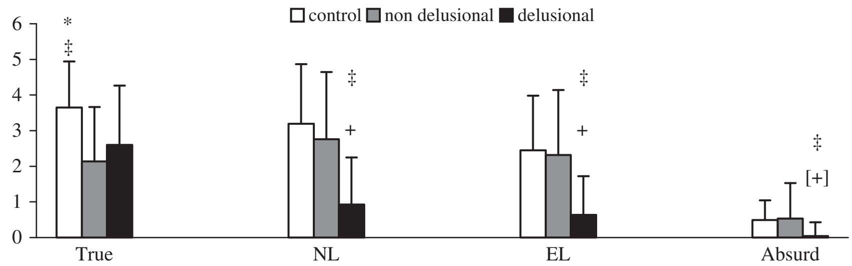

Fig. 3. ANCOVAs for differences between groups in plausibility change (covariate: initial ratings). * = *control* vs. *non-delusional*($P<0.005$), + = *nondelusional* vs. *delusional* (*NL*, *EL*: $P<0.001$; *Absurd*: *trend level*, $P=0.06$), ‡ = *control* vs. *delusional* (*True*, *NL*, *EL*: $P<0.001$; *Absurd*: $P<0.005$).

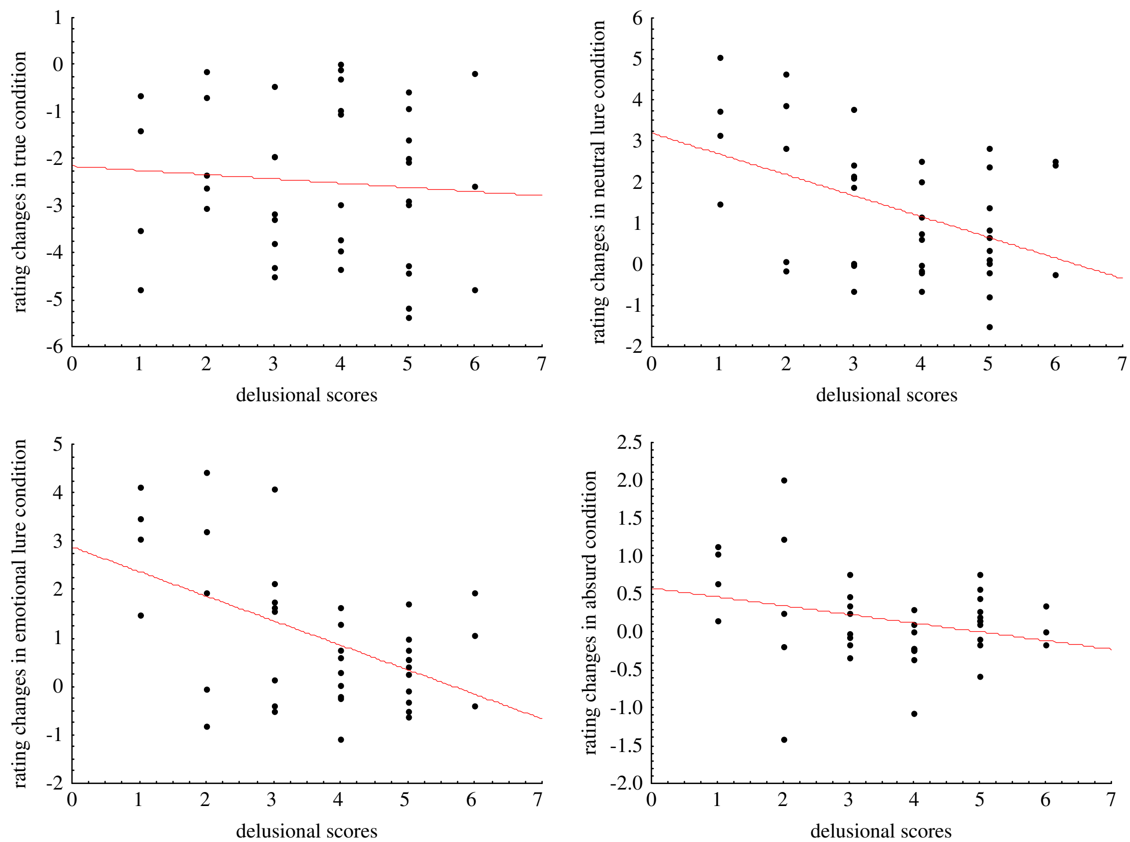

Fig. 4. Scatterplots showing correlations between the delusional scores of patients and plausibility rating changes for each type of sentence.

memory and metamemory in schizophrenia, this pattern of responses has been termed "reduced confidence gap" (Moritz et al., 2008).

The fact that all participants increased plausibility scores for correct interpretations and decreased ratings for incorrect ones from stage 1 to 3, as indicated by repeated measures ANCOVAs, seems to grant for the validity of the task employed.

When splitting the schizophrenia sample on the presence of delusions and controlling for initial belief, BACE and BADE measures showed to discriminate differentially control from schizophrenic participants and delusional from non-delusional patients. Change in plausibility ratings for true interpretations significantly differed between healthy and both currently deluded and not deluded subjects, while the two latter groups did not differ. Conversely, in the NL, EL and absurd conditions a BADE emerged in delusional but not in non-delusional group, whose change in plausibility ratings was comparable to that of controls. So the main result of the present study is that the BACE seems to be an index of knowledge inflexibility ascribable to the diagnosis of schizophrenia while the BADE appears specifically associated with the presence of delusions. The significant correlation and regression found between scores on PANSS delusion item and BADE gave further support to our findings.

As to LA bias and acceptance of absurd explanations, floor effects decreased the power of analysis. A reliable paradigm able to measure this aspect of reasoning is lacking as well as is still to establish whether this judgment bias and the BADE are associated with the degree of delusional conviction.

The correlations between evidence integration performance and neurocognition, psychopathology and ToM skills had an exploratory purpose and require to be replicated. So farcaution with interpretation is needed, given the chance of false-positive findings. Differently from previous researches, we found that BADE significantly correlated with executive functions and ToM abilities. Given the association found between impairement in ToM, reasoning and executive abilities and paranoid delusions (Bentall et al., 2009), maybe this kind of delusions are over-represented in our sample of patients. Reasonably, the complexity of connections between all different cognitive and psychopathological domains thought to play a role in delusions need more

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exhaustive investigation to be solved, possibly with longitudinal studies and larger sample size. Evidence for the efficacy of meta-cognitive rehabilitation focused on reasoning biases are emerging from literature and its combination with cognitive remediation and social cognition training could be a useful application.

The main limitation of the current study was the small sample size of not-deluded subgroup of patients, which counted nine subjects only.

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