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Knowledge corruption for visual perception in individuals high on paranoia

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ABSTRACT

Studies revealed that patients with paranoid schizophrenia display overconfidence in errors for memory and social cognition tasks. The present investigation examined whether this pattern holds true for visual perception tasks.

Nonclinical participants were recruited via an online panel. Individuals were asked to complete a questionnaire that included the Paranoia Checklist and were then presented with 24 blurry pictures; half contained a hidden object while the other half showed snowy (visual) noise. Participants were asked to state whether the visual items contained an object and how confident they were in their judgment. Data from 1966 individuals were included following a conservative selection process.

Participants high on core paranoid symptoms showed a poor calibration of confidence for correct versus incorrect responses. In particular, participants high on paranoia displayed overconfidence in incorrect responses and demonstrated a 20% error rate for responses made with high confidence compared to a 12% error rate in participants with low paranoia scores. Interestingly, paranoia scores declined after performance of the task.

For the first time, overconfidence in errors was demonstrated among individuals with high levels of paranoia using a visual perception task, tentatively suggesting it is a ubiquitous phenomenon. In view of the significant decline in paranoia across time, bias modification programs may incorporate items such as the one employed here to teach patients with clinical paranoia the fallibility of human cognition, which may foster subsequent symptom improvement.

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1. Introduction

For decades paranoid schizophrenia has been judged as psychologically inaccessible, that is, not amenable to understanding. Delusions proper, as Jaspers (1973) called them, were regarded as ideas that could not be derived from any explicable source, for example, biographical factors (Walker, 1991). While the potential contribution of genetic and biological influences to paranoid schizophrenia is undisputed (O'Donovan et al., 2009), new studies have elucidated important psychological mechanisms, for example cognitive biases, that are putatively involved in the formation and maintenance of positive symptoms. Cognitive biases are defined as distortions in the processing, selection and appraisal of information (Moritz et al., 2010). Apart from jumping to conclusions (i.e., patients gather less information for decision-making than controls; for a review see Fine et al., 2007; Garety et al., 1991; Moritz and Woodward, 2005) and a bias against disconfirmatory evidence (i.e., counterevidence is not sufficiently considered for reasoning; Moritz and Woodward, 2006a; Woodward et al., 2007, 2006, 2008), numerous studies have elucidated that patients are also poor in their calibration of confidence (Gaweda et al., 2012; Moritz and Woodward, 2002; Moritz et al., 2008, 2003; Peters et al., 2007). While confidence of those affected by paranoid schizophrenia is usually enhanced for erroneous judgments in comparison to controls, they are often less confident than controls when they are actually correct (the latter bias, however, is less well established). This pattern has been termed reduced "confidence gap" (e.g., Moritz et al., 2003), which in combination with an enhanced error rate culminates in inflated "knowledge corruption" (i.e., the proportion of high confident errors on all high confident responses). In other words, a substantial share of what the

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participant believes to be factual is wrong. It has been argued that this bias may promote paranoid ideation: If patients cannot distinguish between correct and incorrect *subjective facts*, consequential misjudgments up to the point of delusional misconceptions may occur (for a review see Moritz and Woodward, 2006b). Importantly, overconfidence in errors and other biases have been found to be present even in neutral (not delusion-relevant) scenarios, thereby precluding tautological inferences.

Experimental studies on overconfidence in errors have been mainly conducted using memory tests (Gaweda et al., 2012; Moritz and Woodward, 2002; Moritz et al., 2008, 2003; Peters et al., 2007, 2013). More recently, this line of research has been extended to the domain of social cognition. For example, using two face recognition paradigms, we found that patients with schizophrenia are overconfident regarding erroneous social judgments (Kother et al., 2012; Moritz et al., 2012). In our view, (social) errors per se are not problematic if held in check by doubt ("well, that guy over there *seems* angry… let's see what he is up to"). However, if a person is utterly *convinced* about the correctness of his or her judgments, this may prompt serious responses ("That guy over there *is* angry at me – well then: fight or flight?"). To illustrate, in a recent study (Moritz and Van Quaquebeke, 2014) we explored the impact of delusional conviction on emotion and behavior in a psychometric high-risk study by asking participants how they would act or feel if a secret service were after them (fictive scenario), graded for confidence ranging from 20% to 100% conviction. We detected a linear relationship: the higher the level of subjective conviction, the more likely participants considered grave consequences such as arming themselves and being prepared to hurt someone when feeling threatened.

As we have explained in more detail elsewhere (Moritz et al., 2008), a reduced confidence gap likely stems from liberal acceptance, which has also been implicated in the jumping to conclusions bias (Moritz et al., 2007). Studies suggest that patients with paranoia have a lowered threshold for accepting hypotheses as true, thereby limiting the probability to detect evidence that may run counter to their false judgments, while a premature termination of search processes in turn limits chances of finding valid clues for correct judgments (which may potentially decrease confidence judgments; Moritz et al., 2008). Longer search processes and more conservative criteria may not entirely prevent errors but enhance the probability that these will gain less momentum as they are associated with some kind of "not trustworthy" tag (Moritz et al., 2003, p. 137).

For the present study, we were interested in whether overconfidence in errors extends to (non-social) visual perception. Consistent evidence suggests that patients with schizophrenia share problems with perception and perceptual organization, which impacts on important outcomes such as social cognition (Silverstein and Keane, 2011). While deficits have been detected across a wide range of domains, they are perhaps best studied and understood for the visual modality (for reviews see Chen, 2011; Green et al., 2009; Tan et al., 2013; Yoon et al., 2013). However, to the best of our knowledge, response confidence for visual judgments has not been tested before. To address this question, we adopted a psychometric high-risk approach (Chapman and Chapman, 1988, 1985; Lenzenweger and Korfine, 1994): A large number of participants were recruited from the general population and divided into high and mean-to-low scorers on a paranoia scale. This approach is well-established since paranoid ideas are present to a variable degree in the normal population and are not confined to patients with paranoid schizophrenia. According to Freeman (2006), 1–3% of the nonclinical population have clinically relevant delusions; another 5–6% display delusions with milder severity, and a further 10–15% have fairly regular delusional ideation (see also van Os et al., 2009). At least 50% of the population exhibits minor paranoid ideas such as "There might be negative comments being circulated about me" at least once a month (Moritz and Van Quaquebeke, 2014). An advantage of this kind of research over a clinical study with individuals diagnosed with paranoid schizophrenia is that patients are usually medicated with antipsychotic agents that may confound results. Recent cross-sectional studies suggest that higher neuroleptic dosages dampen overconfidence in errors (Moritz et al., 2003), which has been recently replicated experimentally: Nonclinical subjects who were given a small dosage of antipsychotics showed decreased confidence for error responses on a memory task (Andreou et al., 2014).

We expected that participants high on paranoia would commit more errors on a visual illusions task and would show higher confidence in errors than controls. A subsidiary aim of the study was to explore if paranoia scores would decrease following the visual illusions task, as demonstrated previously (Moritz et al., 2014), suggesting that the administration of difficult cognitive items in conjunction with confidence ratings alone may lower delusional ideation.

2. Methods

2.1. Participants and procedure

Participants were recruited by means of WiSo-Panel, a German academic online service providing researchers with the opportunity to advertise scientific studies (for the reliability of data of this and related services see Göritz, 2007; Judge et al., 2006; Piccolo and Colquitt, 2006). The online survey was programmed using "unipark" (Globalpark AG/Questback). The study was announced as an investigation assessing the impact of mood on perception. A total of 11,846 individuals from the general population were invited to participate, out of which 2008 (17%) completed the core part of our study (Paranoia Checklist and illusion paradigm). Blind to analyses, data of 42 participants were discarded who had either entered the same value throughout in the psychopathological scales ($n=21$), had disclosed that they had not responded openly ($n=14$), or had made nonsense entries on the items relating to what objects (if any) they had seen on the illusion test ($n=7$; e.g., "fgjf erzerz") resulting in a total of 1966 participants that were included in the analyses. No financial incentive was paid. Instead, participants were offered downloads of mindfulness and relaxation exercises at the end of the survey.

2.2. Questionnaires

Participants first provided informed consent and were then asked about their age, gender, educational level and current job situation.

Before and after the visual illusion test (see below) we administered a questionnaire comprising three scales that probed for different psychopathological syndromes: paranoia, depression, and obsessive-compulsiveness (see below). Items were presented in random order and were rated on a 5-point Likert scale ranging from "fully applies" to "does not apply at all". On both occasions (i.e., before and after the visual illusion test), the 18 frequency items of the *Paranoia Checklist* (Freeman et al., 2005) were administered. Previous studies have confirmed good psychometric properties for this scale (Freeman et al., 2005; Lincoln et al., 2010a, 2010b). Being indicative of its construct validity, the Paranoia Checklist correlates with the jumping to conclusions bias (Moritz et al., 2012), which is implicated in the pathogenesis of delusions (Fine et al., 2007). Factor analysis (Moritz et al., 2012) indicated that the scale is best represented by two dimensions called suspiciousness ("Bad things are being said about me behind my back") and core paranoia ("I can detect coded messages about me in the press/TV/radio"). In a yet unpublished study (Moritz et al., 2014) the Paranoia Checklist frequency scale had a high test retest reliability while at the same time being sensitive to change (approximately 10% improvement following a short cognitive intervention).

Along with the Paranoia Checklist, we administered the 20-item "Center for Epidemiologic Studies-Depression Scale" (CES-D; Hautzinger and Brähler, 1993; Radloff, 1977) on both occasions. To obscure the rationale of the assessment, 10 items from the 18-item *Obsessive Compulsive Inventory – R* (OCI-R; Foa et al., 2002) were incorporated into the questionnaire. Administration of different scales allowed us to explore whether any effects were specific for paranoia.

2.3. Visual pattern perception (snowy pictures tasks)

Next, participants were asked to complete a variant of the snowy pictures task, which was adapted from Whitson and Galinsky (2008). Participants were

presented a series of 'snowy' (i.e., granulated) pictures (see Fig. 1) in which it is difficult to identify an object. For half of the pictures, the original image had been removed digitally. After being presented one example, participants were asked to complete 24 items without time constraint. For each item, participants endorsed on a four-point Likert scale if an object was contained in the picture or not, graded for degree of conviction ("very sure" or "unsure"). Items showing objects and those without were presented in pseudorandom order. Main outcome parameters were rates of hits and false perceptual judgments as well as confidence for correct versus incorrect judgments.

3. Results

Women (60.3%) and individuals with at least 13 years of formal school education (59.7%) were slightly overrepresented in the sample. Most participants were from Germany (96.8%); the remaining participants were mainly from Austria and Switzerland. Average age was 46.1 years (S.D.=14.5). In accordance with the approach advocated by Chapman and Chapman (Chapman and Chapman, 1988, 1985; Lenzenweger and Korfine, 1994) we divided individuals into high scorers (=at least two S.D. above the mean) and low scorers (=not more than 0.5 S.D. above the mean) on the core paranoia subscale of the Paranoia Checklist as well as the CES-D Depression Score. As can be seen in Tables 1 and 2, individuals high on paranoia showed the predicted response pattern: apart from making more errors (lower accuracy), they showed over-confidence in errors and at the same time indicated somewhat reduced confidence for correct responses, resulting in a small confidence gap relative to low scorers. This in combination with a high error rate led to increased knowledge corruption: 20% of the responses high paranoia scorers considered to be 100% correct, were in fact, wrong, while only 12% of the responses low paranoia scorers considered to be 100% correct, were, in fact, wrong. Results remained significant when the possible confounding factors age and gender (see de Portugal et al., 2010) were controlled for (and became significant in the case of the "% high confident correct/all correct" parameter, which had only achieved a statistical trend level in the uncorrected comparison). No significant difference emerged for participants high versus low on depression.

Results for the paranoia checklist total score and the core paranoia subscale score were largely comparable. Participants high on the paranoia checklist total score also displayed a decreased confidence gap, $t(1610)=2.65$, $p=0.008$, significant knowledge corruption, $t(1622)=2.73$, $p=0.007$, and decreased accuracy, $t(1622)=2.43$, $p=0.015$, relative to low scorers.

Correlational analyses showed that the knowledge corruption index (i.e., the proportion of high confident errors on all high confident responses) and the confidence gap correlated with the core paranoia subscale ($r=0.13$, $r=-0.12$; both $p<0.001$), while it did not with either the paranoia checklist total score ($r=0.04$, $p=0.06$; $r=-0.03$, $p>0.1$) or the depression scale ($r=0.03$, $p>0.2$; $r=0.00$, $p>0.9$). Nonparametric correlations yielded essentially similar results (i.e., significant correlations with the core paranoia scale; insignificant results for depression and the paranoia checklist total score).

3.1. Change over time and predictors of change

The paranoia checklist and core paranoia subscale declined from pre to post (total score pre: $M=28.20$ (S.D.=11.39); post: $M=26.28$ (S.D.=11.43), $t(1963)=18.67$, $p<0.001$; core paranoia pre: $M=6.27$ (S.D.=2.55); post: $M=6.09$ (S.D.=2.46), $t(1963)=5.48$, $p<0.001$). In contrast, the depression score rose slightly (pre: $M=40.08$ (S.D.=15.78), post: $M=42.83$ (S.D.=11.44), $t(1963)=13.17$, $p<0.001$).

When we split the sample into those who improved by at least 1 point on the paranoia checklist ($n=1168$) versus those who did not improve or even worsened ($n=796$), only the number of high



Fig. 1. Example of employed visual material: left panel depicts a hidden sailboat; right panel does not depict any object.

Table 1
Participants scoring high (at least two S.D. above the mean) versus low (not more than 0.5 S.D. above the mean) on the CES-D depression scale.

	M and S.D. of high scorer ($n=104$)	*M* and S.D. of low scorer ($n=1404$)	Statistics
Accuracy			
All correct (i.e., hits and correct rejections)	18.33 (2.20)	18.58 (2.47)	$t=0.98$, $p>0.3$
Hits	7.82 (2.47)	8.14 (2.63)	$t=1.21$, $p>0.2$
False alarms	1.49 (2.17)	1.57 (2.29)	$t=0.35$, $p>0.7$
Metamemory (confidence) parameters[a]			
High confident incorrect	1.95 (2.22)	2.09 (2.49)	$t=0.56$, $p>0.5$
High confident correct	10.74 (4.99)	11.58 (4.72)	$t=1.75$, $p=0.08$
% high confident correct/all correct	58.36 (26.30)	62.62 (24.99)	$t=0.98$, $p>0.3$
% high confident incorrect/all incorrect	32.83 (34.24)	35.89 (35.76)	$t=0.98$, $p>0.3$
Confidence gap in %	26.60 (26.77)	27.24 (26.44)	$t=0.24$, $p>0.8$
Knowledge corruption in %	12.57 (13.10)	12.23 (12.62)	$t=0.27$, $p>0.7$

Notes: Please note that the confidence gap somewhat deviates from the difference between "% high confident incorrect/all incorrect" and the "% high confident correct/all correct" parameter because some participants made no errors at all, so that for these cases neither the latter index nor the confidence gap could be computed.

[a] see manuscript for explanation

Table 2
Participants scoring high (at least two S.D. above the mean) versus low (not more than 0.5 S.D. above the mean) on the "core paranoia" subscale of the paranoia checklist.

	M and S.D. of high scorer ($n=105$)	*M* and S.D. of low scorer ($n=1641$)	Statistics
Accuracy			
All correct (i.e., hits and correct rejections)	17.55 (2.49)	18.60 (2.45)	$t=4.27$, $p<0.001$
Hits	7.11 (2.63)	8.17 (2.57)	$t=4.06$, $p<0.001$
False alarm	1.56 (2.27)	1.56 (2.23)	$t=0.00$, $p>0.9$
Metamemory (confidence) parameters			
High confident incorrect	2.68 (2.61)	1.98 (2.41)	$t=2.87$, $p=0.004$
High confident correct	10.17 (5.50)	11.47 (4.66)	$t=2.36$, $p=0.02$
% high confident correct/all correct	56.82 (29.41)	61.92 (24.68)	$t=1.74$, $p=0.08$
% high confident incorrect/all incorrect	41.53 (36.18)	33.91 (34.65)	$t=2.18$, $p=0.03$
Confidence gap in %	15.29 (24.03)	28.07 (26.01)	$t=4.90$, $p<0.001$
Knowledge corruption in %	20.06 (17.71)	11.93 (12.63)	$t=4.56$, $p<0.001$

Notes: Please note that the confidence gap somewhat deviates from the difference between "% high confident incorrect/all incorrect" and the "% high confident correct/all correct" parameter because some participants made no errors at all, so that for these cases neither the latter index nor the confidence gap could be computed.

confident responses discriminated between these two groups ($t(1962)=2.19$, $p=0.029$), whereby those who improved (i.e., symptom decline) gave fewer high confident responses. For the core paranoia subscale, only 424 participants improved over time. For this subscale, no association with the number of high confident responses was found ($p>0.5$).

3.2. Psychometric properties

Test retest reliability was excellent for all scales (paranoia checklist total score: $r=0.92$; CES-D depression scale: $r=0.81$; core paranoia: $r=0.82$; all $p<0.001$).

4. Discussion

Results suggest that overconfidence in errors and knowledge corruption in paranoia are not only seen in memory (Gaweda et al., 2012; Moritz and Woodward, 2002; Moritz et al., 2008, 2003; Peters et al., 2007) and social cognition (Kother et al., 2012; Moritz et al., 2012) but extend to visual perception. Participants scoring high on paranoia, especially core paranoid items ("My actions and thoughts might be controlled by others"), had a smaller confidence gap (i.e., the difference between confidence for correct judgments versus incorrect judgments). No such association was seen for participants high on depression, supporting the specificity of this relationship. Those scoring high on paranoia showed lower detection rates, which is in accordance with a large literature on perceptual deficits in clinical patients (see Section 1).

We have just started to understand the neuronal basis of overconfidence. For example, neuroimaging studies implicate the cingulate cortex in overconfidence (Chen et al., 2013; Moritz et al., 2006). On a biochemical level, dopamine seems to moderate confidence: hyperdopaminergic transmission may trigger overconfidence (Corlett et al., 2010, p. 360; Lou et al., 2011), while neuroleptic agents blunt confidence according to a recent experimental study (Andreou et al., 2014) as well as self-report investigation (Moritz et al., 2013). Recent models attribute error prediction a central role for explaining the long-held relationship between dopamine and positive symptoms (Fletcher and Frith, 2009; Pankow et al., 2012): spontaneous aberrant dopamine release makes otherwise neutral stimuli salient/meaningful, thereby triggering inferential processes that aim to explain these phenomena. It remains to be examined how confidence fits into this model. The above suggests that dopamine may not only augment the salience of perceptual stimuli but is also responsible for the high conviction associated with delusions.

Interestingly, paranoia severity improved after the task, which is in line with another study (Moritz et al., 2014) demonstrating that a brief task with difficult items that requires participants to grade their degree of confidence may ameliorate delusional ideas. No such effect was seen for depression scores, rendering regression to the mean unlikely. As no control condition was implemented, no strong inferences can be made, however. We speculate that demonstrating participants the fallibility of human judgments and the importance of expressing doubt, if evidence is incomplete, diminishes paranoid ideation.

Greater improvement on the paranoia scale (total score) was associated with the number of doubt responses. In other words, participants who improved on paranoia were less certain about their judgments than those whose paranoia worsened or remained the same on the paranoia checklist upon retest. This is in line with the approach adopted by metacognitive training for people with psychosis (MCT), an example of a bias modification program (see also Ross et al., 2011; Waller et al., 2011), which confronts schizophrenia patients with exercises that lure into false and high confident erroneous responses (Moritz et al., 2013, 2010). Patients are encouraged to consider alternative hypotheses, as well as weighing up supporting and disconfirmatory evidence. This should help to overcome response tendencies like, for example, jumping to conclusions or the confirmation bias (Balzan et al., 2013). By making corrective experiences, the training aims to "plant the seeds of doubt", which is hoped to extend from neutral tasks to delusional ideas (i.e., "Oops, I was wrong there, perhaps I am also mistaken with my special ideas").

We wish to acknowledge a number of limitations. First, participants were selected via the Internet and not interviewed or clinically assessed. While expert assessment is usually favored over self-rating in clinical research (Coyne, 1994), it may also induce biases. For example, participants may not disclose ideas because they fear they could be viewed as strange or repelling by the interviewer (Moritz et al., 2013), or because of distrust (especially in participants high on paranoia). High test retest reliability and good internal consistencies suggest that the quality of the data was high. Still, future studies may incorporate additional "lie" scales such as an infrequency or a social desirability scale. Second, the distinction between participants high versus low on paranoia was made according to an arbitrary criterion (i.e., 2 S.D.s above the mean). While this approach is common practice in US schizotypy research, the British tradition of schizotypy research (for a review see Claridge, 1997) often used smaller samples that are split at the median. We feel, however, that our criterion maximized chances to detect participants with relevant degrees of paranoia. Third, we only tested for paranoid ideas and not other psychotic symptoms. It may be – and we expect it to be so – that

the present findings hold true for other prominent positive symptoms of schizophrenia, such as hallucinations and dysfunctions of ego-boundaries (e.g., thought broadcasting). Finally, we did not determine visual acuity. While this might explain between-groups differences in accuracy it is hard to imagine how this would have resulted in overconfidence in those high on paranoid symptoms.

To conclude, our study shows that paranoia but not depression is associated with knowledge corruption for perceptual illusions in a psychometric high-risk sample. We think that an impairment in calibration for distinguishing correct from incorrect responses by means of confidence represents a core risk factor for the emergence of paranoia and resultant emotional and behavioral problems (Moritz and Van Quaquebeke, 2014). The representation of reality is distorted as a result of the reduced confidence gap, as errors receive overly strong weight while correct judgments are held with less certainty than by controls. Importantly, our study, like forerunner studies on memory and social cognition, employed delusion-neutral material so that we presume that the driving mechanism is a general one and not only elicited by special types of salient information. Patients may not be able to question incorrect responses because of high levels of certainty and because (counter-) information is not sufficiently strong to hold false judgments in check. Interventions that raise patients′ awareness of the fallibility of human judgment and the consequences of highly confident but erroneous judgments may dampen paranoid ideas ("Well, I have been sure before but was in fact wrong… so I should better check twice). In line with this, paranoia scores fell after administration of the task. Randomized controlled trials comparing psychoeducative training against control interventions are needed to clarify whether this improvement is due primarily to an effect of the intervention or whether it reflects other influences (e.g., passage of time, habituation), and in case the former is true, whether effect sustained over time.

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