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Using signal detection theory to test the impact of negative emotion on sub-clinical paranoia

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ABSTRACT

A novel experimental paradigm for measuring state paranoia by means of signal detection theory was evaluated. A liberal response bias, indicating the tendency to recognize facial expressions as threatening, was expected to reflect paranoia. Against theoretical expectations, heightened paranoia questionnaire scores were associated with a non-liberal bias, which was not affected by negative emotion per se. However, subsequent analyses revealed that, if anxious, participants with heightened paranoia adopted a comparatively more liberal response bias. These findings corroborate the eminent role of anxiety in paranoia and demonstrate that state paranoia can be captured with the presented paradigm.

1. Introduction

Persecutory delusions involve the anticipation of harm which is intended by a malevolent persecutor (Freeman & Garety, 2000). Freeman, Garety, Kuipers, Fowler, and Bebbington (2002) proposed a cognitive model of persecutory delusions that explains the formation of delusional threat beliefs in terms of a distorted attribution process. This process is adversely influenced by three factors: anomalous experiences, cognitive biases and emotional disturbances. Negative emotions, particularly anxiety, are assumed to have a direct influence on the formation and maintenance of persecutory delusions (Freeman, 2007; Freeman et al., 2005). They influence a search for meaning of anomalous or unusual experiences, resulting in a persecutory threat belief. Furthermore, negative emotions are supposed to maintain the threat belief by means of safety behavior (Freeman et al., 2007). Several studies have found correlational association between anxiety and paranoia (Freeman & Fowler, 2009; Martin & Penn, 2001; Startup, Freeman, & Garety, 2007). Moreover, in a recent experimental study, anxiety was identified as a mediator of the impact of stress on paranoia (Lincoln, Peter, Schäfer, & Moritz, 2008).

The benefit of the cognitive model of persecutory delusions is the integration of empirical and practical findings in a theoretical framework that allows the deduction of predictions. Surprisingly however, in the last six years there have only been a few *experimental* studies to test the prediction that negative emotions increase paranoia (e.g. Ho-Wai So, Freeman, & Garety, 2008; Lincoln et al., 2008). This lack of testing might be due to the absence of measures of persecutory ideation. So far, solely self-report questionnaires have been available for this purpose (e.g. the Paranoia Scale by Fenigstein & Vanable, 1992; or the Paranoia Checklist by Freeman et al., 2005). These are disadvantageous because of their susceptibility to unquantifiable response biases. Furthermore, they are designed to capture long-term or 'trait' persecutory ideation by response modalities like "once a month" to "at least once a day" (Freeman et al., 2005). Because of this lack of sensitivity they are not appropriate to measure experimentally induced changes. For this reason, in the present study an experimental paradigm for measuring *state* persecutory ideation – in contrast to questionnaires that are denominated as *trait* measures in the following – was developed to allow for experimental testing of models explaining persecutory delusions.

This paradigm is based on the assumption that the persecutory threat belief ("someone intends harm towards me") can bias the perception of the aggression-expressing, threatening emotion anger in faces (Averill, 1983; Öhman, 1986). Because persecutory delusions are "erroneous beliefs that usually involve a misinterpretation of perceptions" (DSM-IV; American Psychiatric Association, 1994, p. 275), it is proposed that they will be related to a bias to perceive other persons as angry (and thus socially

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threatening). In facial anger detection tasks such biases can be described by means of the signal detection theory (Wickens, 2002), with a liberal response bias indicating a tendency to perceive – or to report to have perceived – anger. In the theoretical framework of detection theory a liberal bias implies that the response criterion, i.e. the level of subjective evidence necessary to report having seen an angry face, is relatively low. The main advantage of the signal detection approach is its ability to separate the otherwise confounded aspects of decision behavior: the performance (how well can angry expressions be detected?) and the response tendency (how often are angry expressions chosen in case of uncertainty?). Without a signal detection analysis it is difficult to infer which aspect accounts for the results. For example, it would remain unclear if a higher ratio of correctly recognized angry expressions is due to an improved performance or to a liberal response bias.

Because of the novelty of the paradigm, the study was conducted with undergraduate students without clinical relevant paranoia. In line with a continuum hypotheses of psychotic symptoms (Johns & van Os, 2001) it is expected that associations in clinical levels of persecutory delusions are also present at sub-clinical levels. However, it has to be kept in mind that a simple generalization of sub-clinical findings onto clinically relevant levels of paranoia is improper.

The following study tests the assumption that higher levels of 'trait' paranoia, reflected in higher questionnaire scores, are related to a more liberal and thus paranoia-congruent response bias. Furthermore, in accordance with the cognitive model of persecutory delusions (Freeman et al., 2002), negative emotions, for example anxiety, are expected to amplify the liberal bias in individuals with heightened trait paranoia, because they trigger a paranoid threat belief and thus the anticipation of threat.

2. Method

2.1. Participants

A power calculation was conducted based on a repeated measures ANOVA with within–between interaction (medium effect size $f = 0.25$, $alpha = 0.05$, $power = 0.95$, correlation between measures $r = 0.5$, non-sphericity correction $epsilon = 1$), resulting in a minimal sample size of 44. A total of 53 undergraduate students were recruited via notice-boards in the local psychology department. All participants attended the experiment in partial fulfillment of a university course requirement. Three of them were excluded because of diminished sensitivity to angry faces ($d' < 1$) in at least one condition. Moreover, one participant was removed due to his indication of having felt better in the negative than in the positive emotion evocating condition. The mean age of the analyzed sample ($N = 49$) was $M = 21.9$ (SD = 2.4) with a rate of 87.8% females and 12.2% males.

2.2. Measures

Participants had to absolve a decision task (see 2.4 Procedure). The responses were transformed into the response bias index $\ln(\beta)$, representing the logarithm of the ratio of anger and neutral facial expression likelihoods assuming equal variance, Gaussian distributions (for details, see Wickens, 2002). Negative values of $\ln(\beta)$ indicate a liberal bias, that is a tendency to report to have seen a threatening facial expression, while positive values indicate the contrary. Additionally, the index of sensitivity d' was computed, which reflects the performance of discrimination between angry and neutral expressions.

The Paranoia Checklist (Freeman et al., 2005) and the paranoia and the delusion of reference items (numbers 6–15) of the long version of the Peters et al. Delusions Inventory (PDI; Peters, Joseph, & Garety, 1999) with a simplified yes-no response format were used to assess the trait level of persecutory ideation. The Paranoia Checklist total score was computed by summing up the products of subscale item scores, resulting in a measure that reflects the average level of persecutory thoughts regarding their frequency, conviction and distress (see Appendix A. 1).

A brief manipulation check questionnaire with three items repeatedly measured the effects of the emotion induction. It assessed the valence of the 'emotional state' (*bad–good*), the 'arousal' (*little–a lot*) and the 'attention' (*weary–rested*) using six-point scaling after each experimental condition (instruction: "Please appraise your present feeling after each block").

2.3. Stimulus material

The photorealistic facial expressions were computer-generated (with the software Poser version 5.0, www.e-frontier.com) and verified in a preparatory study ($N = 49$) in an independent sample. Visually, the mild angry expression differed from the neutral by revealing slightly frowning eyebrows, slightly more opened eyes, slightly raised nostril wings, and a compressed mouth (see http://www.uni-marburg.de/fb04/ag-klin/mitarbeiter/westermanns/JBTEP-D-09-00005). The angry expression was indeed judged as more angry (Cohen's $d = 1.52$) according to the preparatory study, less happy ($d = -1.35$), more repulsive ($d = 0.83$), more disgusted ($d = 0.78$), more sad ($d = 0.70$), less surprised ($d = -0.69$) and more anxious ($d = 0.67$) than the neutral expression (all differences significant: $|t(48)| > 4.41$; $p < 0.01$). The occurrence of unspecific medium effect sizes in other facial expression dimensions could not be avoided despite careful visual modeling.

The emotional evocative pictures were categorized into three sets, depending on their valence: positive, neutral and negative. Each set consisted of 150 International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1999) pictures (for a listing of all picture identifiers, see Appendix A. 2). The set characteristics are presented in Table 1 (upper part). The classification of the pictures was conducted in several steps on the basis of valence and arousal norms of Lang et al. (1999). First, stimuli with an arousal PR > 90 were excluded due to the fact that they predominantly depicted violent scenes. Then, the upper and lower 150 pictures of the valence dimension were classified as positive and negative, respectively. Moreover, the 150 pictures close to the mean of the valence dimension were selected as neutral.

Table 1
Characteristics of the used IAPS stimulus material according to dimensional and discrete norms (means with standard deviations in parentheses).

Set	*N*	Dimensional[a]		Discrete[b]		
		Valence	Arousal	Fear	Sadness	Disgust
Positive	150	7.31 (0.41)	5.01 (1.00)			
Neutral	150	5.41 (0.48)	3.93 (1.16)			
Negative	150	2.88 (0.59)	5.53 (0.86)			
Anxiety	12	3.59 (0.31)	6.20 (0.51)	3.29 (0.43)	1.43 (0.24)	2.43 (0.52)
Sadness	27	2.61 (0.49)	5.36 (0.77)	2.55 (0.74)	4.35 (0.59)	2.52 (0.81)
Disgust	36	2.73 (0.60)	5.48 (0.73)	2.44 (0.68)	3.01 (1.18)	4.54 (0.82)

Note. The stimulus set characteristics of the main analysis are presented in the first three rows. For a post-hoc analysis the negative set was further divided into three discrete emotion subsets (lower three rows).
[a] Based on Lang et al. (1999), range 1–9.
[b] Based on Mikels et al. (2005), range 1–7.