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Perceptual biases and positive schizotypy: The role of perceptual load

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Abstract

The study investigated the effects of perceptual load on the bias to report seeing non-existing events—a bias associated with positive symptoms of schizophrenia and positive schizotypal symptoms. Undergraduate students completed psychometric measures of schizotypy and were asked to detect fast moving words among non-words under different levels of perceptual load. Perceptual load was manipulated through stimulus motion. Overall, the results showed that the higher the perceptual load, the stronger the bias to report seeing words in non-word trials. However, the observed bias was associated with positive schizotypy (Unusual Experiences) only when visual detection was performed under conditions of medium perceptual load. No schizotypy measure was associated with accuracy. The results suggest that, although some amount of perceptual ambiguity seems to be necessary for schizotypal bias generation, an increase in the perceptual load can inhibit this process possibly by preventing perception of task-irrelevant internal events, such as loose word associations.

Keywords: Anomalous experiences; Hallucinations; Individual differences in cognitive/perceptual biases; Perceptual load; Schizotypy; Schizophrenia

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1. Introduction

Positive psychotic symptoms, such as hallucinations and unusual perceptual experiences have been associated with a bias towards believing that non-existing stimuli are present (Bentall & Slade, 1985; Cahill, Silbersweig, & Frith, 1996; but see Boecker, Hijman, Kahn, & De Haan, 2000). Such a bias has been also observed in healthy undergraduate students who score highly on psychometric measures of predisposition to hallucinations (Bentall & Slade, 1985; Feelgood & Rantzen, 1994; Jakes & Hemsley, 1986; Rankin & O' Carroll, 1995) and measures of positive schizotypy (Tsakanikos & Reed, 2005a; Tsakanikos & Reed, 2005b), although the cognitive mechanisms underlying this effect are little understood.

A misattribution of internally generated events to external sources (Brebion, Smith, Amador, Malaspina, & Gorman, 1998; Morrison & Haddock, 1997) is thought to be a core feature of positive symptomatology in schizophrenia (Garety, Kuipers, Fowler, Freeman, & Bebbington, 2001). It is possible that a psychotic-like bias towards believing that a non-existing stimulus is present may result from internally generated task-irrelevant stimuli, such as loose word associations, being attributed to an external source. This account is supported by two independent lines of evidence. The first line of evidence suggests that positive schizotypal symptoms predict an increased generation of word associations (Miller & Chapman, 1983; Tsakanikos & Claridge, 2005). Loosening of associations in schizophrenia (e.g., Kwapil, Hegley, Chapman, & Chapman, 1990; Levine, Schild, Kimhi, & Schreiber, 1996) and positive schizotypy (Mohr, Graves, Gianotti, Pizzagalli, & Brugger, 2001) has often suggested to be the result of enhanced spreading activation in semantic networks (Spitzer, Braun, Hermle, & Maier, 1993). The second line of evidence suggests that people with schizophrenia, as well as high-schizotypy scorers, are relatively impaired in their ability to ignore task-irrelevant stimuli (e.g., Braff, 1993; Nestor & O'Donell, 1998). Considering that positive schizotypal symptoms predict a bias to report seeing non-existing words during brief presentations of fast moving non-words (Tsakanikos & Reed, 2005a, 2005b), it is conceivable that such a bias may be due to a failure to ignore internally generated, task-irrelevant, stimuli (i.e., loose word associations generated during brief visual exposure to non-words) attributed to an external source (i.e., computer screen).

Very little is known about the external parameters that modulate psychotic-like biases. For example, it remains unclear whether generation of such biases depends on how difficult it is to detect an event. The amount of cognitive/perceptual difficulty in which a visual stimulus can be detected is often referred to as perceptual load. Research on perceptual load has been based on the premise that, although perception has limited capacity, it processes all inputs automatically until it runs out of capacity. As a result, high perceptual load engages full capacity in processing task-relevant stimuli, leaving no spare capacity for perception of task-irrelevant stimuli (see Lavie, 2005 for a review). If internally generated task-irrelevant events, such as word associations, were necessary for the generation of a bias towards believing that a non-existing stimulus is present then preventing perception of such events should eliminate bias generation. One method for preventing perception of task-irrelevant stimuli is to experimentally increase the perceptual load through stimulus motion (Rees, Frith, & Lavie, 1997). Consequently, the main aim of the present study was to examine the effects of perceptual load (experimentally manipulated through stimulus motion) on bias generation associated with schizotypal traits.

2. Method

2.1. Participants

Eighty undergraduate psychology students (25 males and 55 females) took part in the study. The average age was 19.8 years, ranging from 18 to 23 years. All the participants had normal or corrected-to-normal (i.e., wearing glasses or contact lenses) vision. None of them admitted psychiatric or neurological history or psychoactive medication use.

2.2. Design

This was a within-subject design with three levels of perceptual load. The experimental task was a variant of a visual search paradigm (Tsakanikos & Reed, 2005a, 2005b). Following Rees et al. (1997), the level of perceptual load was manipulated through increasing the stimulus motion (i.e., animated images presented at different speeds). Apart from the experimental task, the participants also completed a number of self-report measures.

2.3. Self-report measures

The Oxford-Liverpool Inventory for Feelings and Experiences (O-LIFE; Mason, Claridge, & Jackson, 1995) includes four scales following various factor analytic studies that revealed 3–4 factors underlying the construct of schizotypy (Bentall, Claridge, & Slade, 1989; Vollema & van den Bosch, 1995). The first three scales correspond to a three-factor model of schizophrenia (Liddle, 1987): 'positive' (Unusual Experiences: 30 items; $\alpha = 0.89$), 'negative' (Introvertive Anhedonia: 27 items; $\alpha = 0.82$), and 'disorganised' (Cognitive Disorganisation: 24 items; $\alpha = 0.87$). The unusual experiences scale consists of items assessing mainly atypical beliefs and unusual perceptual experiences (e.g., 'When in the dark do you often see shapes and forms even though there is nothing there?' 'Are your thoughts sometimes so strong that you can almost hear them?'). The fourth scale (Impulsive Non-conformity: 23 items; $\alpha = 0.77$) refers to the impulsive, aggressive and asocial aspects of psychosis, largely based on the Psychoticism scale (Eysenck & Eysenck, 1975). This scale was included in the present analysis in order to evaluate the possibility of an increased false alarm rate as the result of impulsive tendencies often associated with psychotic-like characteristics. The total score for each schizotypy scale is based on the endorsement (yes/no) of the items. Attesting to their experimental validity of the O-LIFE, high-schizotypy scorers, as identified by these scales, demonstrate neuro-cognitive irregularities akin to those seen in schizophrenia patients (e.g., Burch, Steel, & Hemsley, 1998; Rawlings & Goldberg, 2001; Tsakanikos & Claridge, 2005).

The O-LIFE inventory also included the Lie scale of the Eysenck Personality questionnaire (EPQ; Eysenck & Eysenck, 1975). The Lie scale was used in this study to evaluate the possibility of false alarms resulting from a tendency to respond in a socially desirable way in order to 'please' the experimenter.

2.4. Stimuli and apparatus

Each participant received a total of 96 trials (32 trials in each condition) as a continuous sequence of short animated sequences. Half of the trials contained a word among non-words (word trials) and half of them contained only non-words (non-word trials). Each trial depicted a display of four round blocks, one in each quadrant of the computer screen, which were identical in size to one another. The screen background was black, the blocks were grey, and the letters were white. In each block, there was either a non-word or a real word. The words were five-letter concrete nouns matched for frequency of occurrence (e.g., *PILOT*, *BREAD* etc.). The non-words were meaningless five-letter strings (e.g., *NGFWU*, *WTXYD* etc.).

A three-dimensional model package (3-D Studio) was employed to create the animations, which then were presented with a multimedia animator player (Autodesk Animator Player for Windows Version 1.0). The animations produced an impression of motion such that the four-block configuration appeared to loom rapidly from a distance towards the observer. Each animation was composed of 61 frames and was presented at a rate of 7 (slow speed) 9 (medium speed) or 11 frames/sec (high speed) depending on the experimental condition. Presenting more frames per second (e.g., 11 frames/s) produced an impression of a faster motion (i.e., the words appeared to move rapidly towards the observer) than presenting fewer frames per second (e.g., 7 frames/s).

2.5. Procedure

The participants were tested in individual cubicles equipped with PC monitors. They were instructed to report *yes* when they saw a real word (word trials) and report *no* when they did not see a real word (non-word trials). Trials fell into three levels of perceptual load: low (7 frames/s), medium (9 frames/s) and high (11 frames/s). There was a time restriction in responding, as the participants had to respond during each trial (duration for each type of trial: low load = 8.7 s, medium load = 6.8 s and high load = 5.5 s). Accuracy (*yes* responses during the word trials) and false alarms (*yes* responses during non-word trials) were the dependent variables. Detailed information about the purpose of the study was given after the end of the session. Half of the participants received at the outset the schizotypy measures and then the detection task. The other half received the tasks in the opposite order. At the time of testing, the experimenter was unaware of the schizotypy level of the participants.

3. Results

Table 1 presents the means, standard deviations, and inter-correlations between the O-LIFE scales. The data were comparable to these reported in past studies (e.g., Mason et al., 1995; Rawlings & Goldberg, 2001; Tsakanikos, 2004; Tsakanikos & Claridge, 2005).

Fig. 1 presents false alarms (panel A) and accuracy (panel B) as a function of perceptual load. Inspection of Fig. 1 suggests that false alarms were gradually increased, although accuracy (correct responses) decreased as perceptual load increased. In order to confirm these observations, and also assess the possible effects of the schizotypy measures, the data were analysed by repeated-

Table 1
Means and standard deviations of the schizotypy scales (Oxford-Liverpool Inventory of Feeling and Experiences), and their inter-correlations

Schizotypy scale	*M*	SD	1	2	3
1. Unusual experiences	8.9	5.47	–		
2. Cognitive disorganization	12.35	6.07	0.43**	–	
3. Introvertive anhedonia	4.18	3.36	0.09	0.27*	–
4. Impulsive nonconformity	9.20	3.76	0.36**	0.35**	0.08

* $P < 0.05$ (two-tailed).
** $P < 0.01$ (two-tailed).

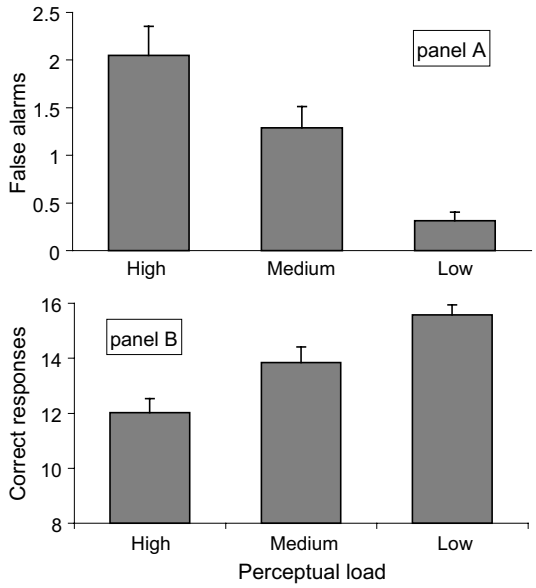

Fig. 1. False alarms (panel A) and accuracy (panel B) as a function of perceptual load.

measures ANCOVAs with Perceptual load as a within-subject factor and the schizotypy measures as covariates. For false alarms, there was a significant effect of Perceptual load ($F_{(2,150)} = 3.75$, $P < .05$) and a significant perceptual load × unusual experiences interaction ($F_{(2,150)} = 3.63$, $P < .05$). Pearson's *r* correlations performed between the above measures revealed a statistically significant correlation between unusual experiences and 'medium' perceptual load ($r = .33$, $P < .01$). For accuracy, there was a significant effect of Perceptual load ($F_{(2,150)} = 5.59$, $P < .01$) but there was no significant interaction with any of the covariates (all Ps $> .10$). No schizotypy measure was associated with accuracy in line with previous studies (Bentall & Slade, 1985; Rankin & O' Carroll, 1995; Tsakanikos & Reed, 2005b).

Accuracy did not correlate significantly with false alarms (Ps $> .10$), suggesting an absence of a systematic trade-off between the two measures. The effect of task order was not statistically sig-

nificant across conditions (t values <1). Similarly, the correlation between score on the Lie scale (social desirability) and the dependent measures was not statistically significant ($Ps > .30$).[1]

4. Discussion

During visual detection of fast moving words undergraduate students showed a bias towards believing seeing words in non-word trials. Students with elevated positive schizotypy scores were particularly prone to such a bias, although their accuracy remained intact. These findings replicate and extend evidence from studies that employed auditory stimuli (Bentall & Slade, 1985; Rankin & O'Carroll, 1995). Similar results have been obtained in a variant of the present paradigm (Tsakanikos & Reed, 2005a, 2005b), as well as in other paradigms that employed abstract visual stimuli (Feelgood & Rantzen, 1994; Jakes & Hemsley, 1986).

Psychotic-like perceptual experiences are likely to be exaggerations of processes modulating normal perception, at least to some extent. On average, each participant saw 1–2 words that never appeared in the trials, although high-schizotypy scorers were more inclined to see such words under medium level of perceptual load. Fundamental decision-making processes are thought to be involved in normal perception (Nakayama, 2001) and similar mechanisms on how decision-making may interact with perception are central to several cognitive models of hallucinations (e.g., Behrendt, 1998; Boecker et al., 2000; Grossberg, 2000). It has been suggested (Garety et al., 2001) that schizophrenic patients are inclined to accept the possibility (decision-making) that an internally generated event, such as a 'voice', is an externally generated stimulus (perception). Likewise, high schizotypal students in the present study were perhaps inclined to decide that internally generated events, such as word associations triggered by non-words, were external events.

Overall, the cognitive/perceptual difficulty of the task enhanced bias generation, as more biased responses were made under conditions of high perceptual load. Nevertheless, such biases were predicted by symptoms of positive schizotypy only under conditions of medium perceptual load. This is a novel finding suggesting that, although some degree of perceptual ambiguity (medium load) is necessary for the generation of psychotic-like biases, when detection of events becomes either effortless (low load) or cognitively demanding (high load), generation of such biases can be prevented in those with positive schizotypal symptoms. Despite that both extreme load conditions prevented psychotic-like bias generation, the mechanism responsible for this is likely to be different: low perceptual load lacked the appropriate amount of perceptual ambiguity and high perceptual load perhaps exceeded it. Considering that high perceptual load prevents perception of irrelevant stimuli (Rees et al., 1997; see also Lavie, 2005), the same mechanism may also explain the effects of high perceptual load on psychotic-like biases: high perceptual inhibited bias generation by preventing perception of irrelevant word associations generated during the speeded presentation of non-words. Non-words (e.g., 'ZBRWH') may have triggered word associations (e.g., 'ZEBRA') perception of which may have been prevented under conditions of high perceptual load (see also Section 1).

[1] Signal detection analysis was further performed on accuracy and false alarms to calculate estimates of sensory sensitivity (d') and response bias (β and c), and statistical analyses were re-run. The main findings were not altered therefore only results from the untransformed data are reported.

The result that the perceptual biases overall were found to be a positive function of perceptual load, although psychotic-like perceptual biases were only observed under conditions of medium perceptual load, deserves some attention, as this dissociation seems to suggest that psychotic-like experiences cannot be interpreted *entirely* as exaggerations of processes modulating normal perception. In the high load condition, for example, everyone (i.e., those with and without positive schizotypal symptoms) seemed to be inclined to report seeing a word in non-word trials.

If cognitive biases are responsible for the maintenance of certain positive symptoms of schizophrenia, then voluntary increase in perceptual load (e.g., carrying out a cognitively demanding/high load task during a hallucinatory experience) may have a detrimental effect on the intensity of occurring symptoms. Importantly, identifying the parameters that modulate perceptual biases in clinical and non-clinical participants has the potential to enhance our understanding about the formation and the maintenance of hallucinations, and perhaps of other anomalous experiences.

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