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Selective impairment of global motion integration, but not global form detection, in schizophrenia and bipolar affective disorder

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ABSTRACT

Recent evidence suggests that schizophrenia is associated with impaired processing of global visual motion, but intact processing of global visual form. This project assessed whether preserved visual form detection in schizophrenia extended beyond low-level pattern discrimination to a naturalistic form-detection task. We assessed both naturalistic form detection and global motion detection in individuals with schizophrenia spectrum disorder, bipolar affective disorder, and healthy controls. Individuals with schizophrenia spectrum disorder and bipolar affective disorder were impaired relative to healthy controls on the global motion task, but not the naturalistic form-detection task. Results indicate that preservation of visual form detection in these disorders extends beyond configural forms to naturalistic object processing.

Schizophrenia is characterised by widespread perceptual abnormalities (Butler et al., 2008; Heinrichs and Zakzanis, 1998; Javitt, 2009). In particular, individuals with schizophrenia show problems with tasks requiring integration of spatiotemporally local stimulus elements into coherent context-sensitive percepts (Silverstein and Keane, 2011; Uhlhaas and Silverstein, 2005). In the temporal domain, whilst local motion perception shows no impairment, integration of local elements into a global percept of motion is compromised in schizophrenia (Chen et al., 2003). This effect could be mediated by a general failure to effectively integrate signals across both space and time; this theory suggests that as well as global motion, global form processing may be impaired in schizophrenia (e.g. Keane et al., 2014). However, a recent comparison of form and motion perception using dot-patterns suggested a greater motion deficit than form perception deficit in schizophrenia (Brittain et al., 2010), implying some dissociation between the two domains. In the present study we investigated this question by studying a naturalistic form-detection task in schizophrenia and healthy controls, and comparing performance on this task to performance on a standard motion integration task. The form-detection task assessed detection sensitivity for two natural object types—faces and flowers—thereby also testing the hypothesis that schizophrenia is associated with a specific face processing deficit (Chen et al., 2008; Frith et al., 1983; Williams et al., 1999). In addition, we also assessed individuals with bipolar affective disorder, to test the hypothesis that these patients experience patterns of visual deficits similar to those with schizophrenia (Carter et al., submitted; Hill et al., 2014).

Participants were inpatients in an acute adult psychiatry inpatient unit in Melbourne, Australia, and were compared to age-matched healthy controls from the general population. Inpatients had a primary diagnosis of either a schizophrenia spectrum disorder (SSD; schizophrenia, schizoaffective disorder or schizophreniform disorder) or bipolar affective disorder. Diagnoses were made independently of investigators by a consultant psychiatrist and multidisciplinary clinical team using DSM-IV criteria. Exclusion criteria were intellectual disability, traumatic brain injury, stroke, or neurodegenerative disease. Additional exclusion criteria for healthy control participants were psychotropic medication or illicit substance use within two weeks of testing, or personal history of psychiatric illness. All participants had normal or corrected-to-normal vision. Participants gave informed consent, and research protocols were approved by Melbourne Health and University of Melbourne Human Research Ethics Committees. Participants' IQ was estimated using the National Adult Reading Test (NART; Blair and Spreen, 1989; Crawford et al., 1992), and handedness was assessed using the Edinburgh Handedness Inventory (Oldfield, 1971). Benzodiazepine doses were converted to diazepam equivalents, and antipsychotic doses were converted to chlorpromazine equivalents (Bezchlibnyk-Butler et al., 2013; Woods, 2003). Table 1 presents summary demographic statistics.

In the form perception task, participants reported the presence or absence of objects (faces or flowers; Fig. 1) in visual noise arrays (Partos

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Table 1
Participant demographic characteristics for form and motion tasks[*].

	Schizophrenia spectrum disorder	Bipolar affective disorder	Healthy control
n completing form task	22[a]	11[b]	13
n completing motion task	14[c]	8[d]	35
Gender (form)	17 M, 5 F	5 M, 6 F	6 M, 7 F
Gender (motion)	11 M, 3 F	5 F, 3 M	20 M, 15 F
Handedness (form)	21R, OL, 1A	10R, 1 L	13R, 0 L, 0A
Handedness (motion)	13R, 0 L, 1A	8R, 0 L	32R, 2 L, 1A
Age [SEM] (form)	38.91[3.06]	40.45 [3.80]	40.38 [3.81]
Age [SEM] (motion)	40.00 [3.94]	41.75 [4.67]	39.11 [2.28]
IQ estimate[e] [SEM] (form)	103.22 [2.55]	102.23 [3.61]	111.6 [2.61]
IQ estimate [SEM] (motion)	98.26 [2.48]	104.01 [4.57]	108.87 [3.50]
Chlorpromazine dose [mg] [SEM] (form)	569.93 [65.68]	404.09 [66.58]	–
Chlorpromazine dose [mg] [SEM] (motion)	552.25 [97.65]	364.00 [55.64]	
Benzodiazepine dose [mg] [SEM] (form)	19.89 [7.31]	15.45 [5.11]	–
Benzodiazepine dose [mg] [SEM] (motion)	19.11 [8.17]	17.5 [6.75]	
DOI[f] [days] [SEM] (form)	4168.8 [684.31]	3620.82 [1107.83]	–
DOI [days] [SEM] (motion)	4420.89 [942.85]	3563.13 [1003.33]	

[*] All inpatients completed the form task, and a subset of inpatients also completed the motion task. Two healthy control participants completed both form and motion tasks.
[a] Including 18 with schizophrenia, three with schizoaffective disorder, and one with schizophreniform psychosis.
[b] Including ten participants in a manic episode at time of testing, and one in a depressed episode.
[c] Including 12 with schizophrenia, one with schizoaffective disorder, and one with schizophreniform psychosis.
[d] Including seven participants in a manic episode at time of testing, and one in a depressed episode.
[e] Due to dyslexia or illiteracy, IQ estimates were not available for two individuals in the schizophrenia group. In addition, two healthy control participants did not complete the NART.
[f] Duration of illness (DoI), calculated as elapsed days from assignment of current diagnosis to day of testing for patients with more than one admission; for first episode patients DoI was calculated from the day of admission to day of testing.

et al., submitted). Stimuli were 12.3 × 12.3 cm 8-bit greyscale arrays, subtending 12.3 × 12.3° visual angle. Sensitivity was measured as d', and response bias as c (Stanislaw and Todorov, 1999; Tanner and Swets, 1954).

In the motion integration task, participants reported the direction of motion (left or right) of coherently moving 'signal' dots amongst randomly moving 'noise' dots (Newsome and Pare, 1988). Stimuli were 9 × 9 cm visual displays subtending 9 × 9° visual angle, containing 300 black and white dots on a grey background (Fig. 2). Sensitivity was calculated as the inverse of coherence threshold.

Form and motion tasks were completed in separate sessions, with task order counterbalanced between participants. Participants were seated comfortably in a dimly lit room, using a chin rest 57 cm from the monitor. Participants verbally reported responses to a researcher, who entered responses into the testing computer. Prior to each task participants completed a practice block with accurate task feedback. No feedback was provided during testing.

In form detection, a 3 × 2 mixed-design ANOVA revealed no significant effect of diagnostic group (schizophrenia spectrum disorder, bipolar, control) on sensitivity, $F(2,42) = 1.07$, $p = .35$ (Fig. 3a). However, there was a main effect of image type, with poorer sensitivity for faces (M = 1.32, *SEM* = 0.07) than flowers (M = 1.46, *SEM* = 0.09), $F(1,42) = 4.44$, $p < .05$, $\eta_p^2 = .10$. However, the interaction between diagnostic group and image type was not significant, $F(2,42) = 1.01$, $p = .37$, indicating that this pattern was observed across all diagnostic groups and is therefore likely to reflect differences in stimulus properties (such as symmetry) rather than visual pathology. This is consistent with the view that schizophrenia is associated with extensive general visual impairments, rather than a specific face-processing deficit (Darke et al., 2013). A second 3 × 2 mixed-design ANOVA revealed a main effect of image type on response bias, $F(1,42) = 7.07$, $p < .05$, with participants more likely to report seeing faces than flowers. However, there was no main effect of diagnostic group on response bias, $F(2,42) = 0.23$, $p = .79$,

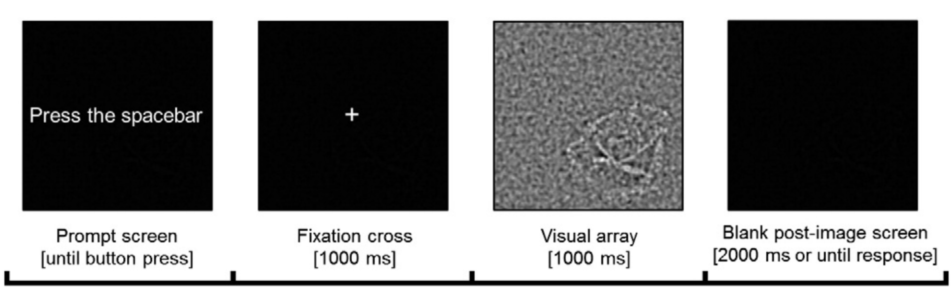

Fig. 1. Schematic diagram of presentation sequence for a single trial during the form perception task. Participants were required to report whether a target object (either a face or a flower) was present in a visual array. 'Object absent' stimuli were noise arrays with a reciprocal amplitude to spatial frequency (1/f) structure, approximating visual statistics of natural scenes (Field, 1987), filtered to contain one octave of frequencies centred on 2.4 c/°, 'Object present' stimuli were similar noise arrays with a percentage of pixels from an object image replacing noise pixels in a portion of the image prior to filtering. All stimuli were filtered and scaled similarly, thereby ensuring similar root-mean-square contrast in 'present' and 'absent' stimuli. Participants completed four blocks of 120 trials, each containing 60 'object present' and 60 'object absent' trials. Stimuli were presented for an extended period of time (1000 ms) and ease of detection was manipulated by systematically varying the percentage of visual noise in 'object present' arrays (equal numbers 55/57/60%, randomly intermixed). The location of the object within the noise was randomly assigned on each trial (equating approximately to a location within one of the 4 quadrants of the image). Participants were correctly informed that half of trials contained objects. Faces and flowers were presented in separate blocks, and participants were told prior to each block whether the block's target objects were faces or flowers. As a result of computer error, data for flower blocks were unavailable for one participant.