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Research paper

# The influence of schizotypal traits on attention under high perceptual load

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A B S T R A C T

Schizophrenia Spectrum Disorders (SSD) are known to be characterised by abnormalities in attentional processes, but there are inconsistencies in the literature that remain unresolved. This article considers whether perceptual resource limitations play a role in moderating attentional abnormalities in SSD. According to perceptual load theory, perceptual resource limitations can lead to attenuated or superior performance on dual-task paradigms depending on whether participants are required to process, or attempt to ignore, secondary stimuli. If SSD is associated with perceptual resource limitations, and if it represents the extreme end of an otherwise normally distributed neuropsychological phenotype, schizotypal traits in the general population should lead to disproportionate performance costs on dual-task paradigms as a function of the perceptual task demands. To test this prediction, schizotypal traits were quantified via the Schizotypal Personality Questionnaire (SPQ) in 74 healthy volunteers, who also completed a dual-task signal detection paradigm that required participants to detect central and peripheral stimuli across conditions that varied in the overall number of stimuli presented. The results confirmed decreasing performance as the perceptual load of the task increased. More importantly, significant correlations between SPQ scores and task performance confirmed that increased schizotypal traits, particularly in the cognitive-perceptual domain, are associated with greater performance decrements under increasing perceptual load. These results confirm that attentional difficulties associated with SSD extend subclinically into the general population and suggest that cognitive-perceptual schizotypal traits may represent a risk factor for difficulties in the regulation of attention under increasing perceptual load.

## 1. Introduction

Recent evidence suggests that the clinically defining positive (hallucinations, disorganised thought, delusions) and negative (apathy, impoverished speech, lack of drive, anhedonia, social withdrawal) symptoms of Schizophrenia Spectrum Disorders (SSD) represent the extreme ends of otherwise normally distributed schizotypal traits in three independent functional domains: Cognitive-perceptual, Interpersonal, and Disorganisation (Raine, 1991). If this *spectrum* view of SSD is correct, schizotypal traits in the general population should be associated with changes in associated cognitive domains (Ettinger et al., 2015).

One of the abnormal cognitive domains that has been frequently reported in SSD is selective attention (Andreasen, 1999; Ettinger et al., 2015). For instance, slower responses have been reported in visual search tasks where participants have to locate a target stimulus among varying numbers of distracters (Carr et al., 1998). Difficulties in the shifting of attention (Bellgrove et al., 2003) and in inhibiting task-irrelevant information have also been documented (Fuentes et al., 1999; Fuller et al., 2000; MacQueen et al., 2003; Salo et al., 1996). Gold et al., 2007 have argued that the source of these abnormalities does not lie in the *selection* of information for attention, but in the top-down regulation of selective attention by executive control processes. On Posner cueing tasks (Posner, 1980), in which participants need to respond as quickly as possible to the location of a target stimulus that is preceded by a cue, patients with schizophrenia demonstrate response time benefits and costs for valid and invalid cues that are comparable to control participants (Bustillo et al., 1997; Gouzoulis-Mayfrank et al., 2007; Pardo et al., 2000). Although their response times are slower overall, this sensitivity to cues demonstrates a preserved ability to selectively attend to likely target locations, which has also been shown on visual search tasks (Elahipanah et al., 2008; Gold et al., 2009). By contrast, abnormalities tend to arise when tasks require top-down regulation of attention, such as when cues in the Posner paradigm are designated to indicate the opposite location for the target (Maruff et al., 1998) or when attention to salient cues needs to be inhibited in anti-

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saccade (Radant et al., 2010) or negative priming tasks (Fuller et al., 2000; Salo et al., 1996).

Despite considerable evidence that the executive control of attention is a source of difficulty in SSD (Gold et al., 2007), some evidence suggests that additional factors contribute to atypical patterns of selective attention. Specifically, under some circumstances individuals with SSD are, seemingly, better at allocating attention to task-relevant stimuli. In rapid serial visual presentation (RSVP) paradigms, where participants need to identify a target among a series of rapidly presented distractors, individuals with schizophrenia are less likely than matched controls to miss-report the distractors as targets (Boucart et al., 2000). Giersch et al. (2002) also observed reduced interference from non-pertinent information in SSD during certain orientation matching tasks in which pertinent and non-pertinent information was physically separated. From an executive function perspective, this would indicate enhanced rather than reduced ability to inhibit task-irrelevant information.

Lavie's (2005, 1995) perceptual load theory of selective attention may help to reconcile the above pattern of findings. According to Lavie, our ability to effectively allocate attention to task-relevant information (and filter irrelevant information) critically depends on the perceptual demands of the task. A low perceptual load results in an automatic ‘spill over’ of available resources to the processing of task-irrelevant information, whereas a high perceptual load prevents such spill-over and processing is limited to basic task-relevant features. Lavie's load theory has been supported by a number of behavioural (Murphy et al., 2016) and neurophysiological studies (Muggleton et al., 2008; Rees et al., 1999) and has proven valuable for understanding attention abnormalities in other disorders such as Autism Spectrum Disorder (ASD; Fairnie et al., 2016; Remington et al., 2009, 2012; Remington and Fairnie, 2017).

Interestingly, there have been reports that ASD is associated with *increased* perceptual capacity (Remington et al., 2009, 2012; Remington and Fairnie, 2017), whereas the evidence in SSD would lead to the prediction of decreased perceptual capacity. Specifically, limitations in perceptual capacity could explain the paradoxical finding of seemingly enhanced inhibition of task-irrelevant information when, in fact, there may simply be insufficient perceptual resources available to ‘spill over’ to the processing of such information in the first place. Minassian et al. (2004) have provided preliminary support for this by measuring pupil dilation to stimuli under conditions of varying perceptual load. Pupil dilation is thought to reflect attentional resource allocation (Beatty and Jackson, 1982) and compared to controls, participants with schizophrenia exhibit larger pupil dilation to low-load stimuli.

To our knowledge, only one study has examined perceptual load in SSD. Ducato et al. (2008) asked participants either to identify a black square (low-load task), to locate the larger number between two one-digit numbers (medium-load condition), or to locate the larger number between two several digit numbers (high-load condition) whilst two disks (distractors) simultaneously moved across the screen. All groups showed greater response times in the low load condition, indicating that perceptual resources spilled over to distractor processing, which thus caused interference with the principal task. However, whereas controls only resisted such interference in the high-load condition, patients with schizophrenia and those high on schizotypal traits demonstrated release from interference in both the medium and high load conditions. This suggests that the full spectrum of schizotypy is characterised by reduced perceptual capacities that are exceeded at lower levels of perceptual load.

The aim of the present study is to further test if limited perceptual capacities contribute to abnormal selective attention in schizotypy, but using a dual task paradigm that tests the effects of perceptual load on the ability to detect a peripheral stimulus (rather than to inhibit distracters). Typically, higher perceptual load in such paradigms leads to longer reaction latencies on the central task and also reduced peripheral stimulus detection (Macdonald and Lavie, 2008). Schizotypal traits should therefore be associated with even longer reaction latencies and poorer peripheral target detection at lower levels of perceptual load. Given the observation of the opposite pattern in ASD (Remington et al., 2009, 2012), and the suggestion that ASD and SSD share common etiological mechanisms (Fatemi et al., 2005; King and Lord, 2011; Rapoport et al., 2009), we tested this prediction whilst controlling for autistic traits.

## 2. Method

### 2.1. Participants

Seventy-four adults with normal or corrected to normal vision participated in this study (46 female: 28 male, age M = 27.5 years, SD = 8.03 years). The majority were recruited from the student population at the host institution where they were reimbursed with course credits. All procedures were approved by the host Department's ethics committee and all participants provided informed consent.

### 2.2. Materials & design

Schizotypal traits were measured using the 74-item Schizotypal Personality Questionnaire (SPQ: Raine, 1991) which has a robust three-factor structure to measure cognitive-perceptual, interpersonal and disorganisation schizotypal traits (Raine et al., 1994; Wuthrich and Bates, 2006). An SPQ total of 41 is typically used as the cut-off point for significant high Schizotypy (Raine, 1991). To control for the possible influence of sub-clinical autistic traits on task-performance (Remington et al., 2009, 2012; Remington and Fairnie, 2017), participants completed the 50-item Autism-Spectrum Quotient (AQ; Baron-Cohen et al., 2001), which examines traits commonly associated with ASD.

The experimental task was modelled on the study of Remington et al. (2012) and was presented using E-prime 2.0 on a Dell 17-inch LCD monitor with a 2 ms refresh rate at a viewing distance of 60 cm. Each trial involved the presentation of either 1, 3 or 6 letters around the circumference of an imaginary circle in the centre of the monitor with a radius of 1.7° visual angle (VA). One of these items was a target letter (X or N) with the other positions occupied either by distracter letters (Z, H, K, Y or V) or a dot (.) place holder. Letters measured 0.6° × 0.6° VA and the place holder 0.2° × 0.2° VA. The locations of the target, the distracters and the place holders were counterbalanced across trials.

On 50% of trials, a peripheral stimulus (PS: #) measuring 0.3° × 0.3° VA, was randomly presented in one of six positions of a larger imaginary circle with a radius of 5.4° VA. Items in the inner circle were presented in black on a light grey background (RGB values: 204, 204, 204) and the PS was a darker grey (RGB: 153,153,153). A total of 72 unique trials could be generated, comprising 12 PS-absent and 12 PS-present trials for each set size, and for each of the target letters (X or N) in the 6 possible central circle positions. These 72 trials were repeated across three runs separated by a short break. Within runs, trials of different set sizes were grouped into mini blocks, the order of which was counterbalanced across runs using a Latin square. 12 additional trials at each set size served for practice at the beginning of the experiment and another block of 12 trials of each set size was presented at the end as a control condition to ensure participants could detect the PS when ignoring the central task.

### 2.3. Procedure

Each trial started with a 1000 ms fixation cross. The central circle of letters then followed for 600 ms and within the first 100 ms of this display the PS square could also appear before being masked by a peripheral black mesh pattern. A blank screen then cued participants to indicate whether the X or N had appeared in the central locations by pressing the ‘A’ or ‘S’ keys on the keyboard as quickly and accurately as possible. Following this response, a screen with a question mark served

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