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Higher proneness to multisensory illusions is driven by reduced temporal sensitivity in people with high schizotypal traits

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ABSTRACT

A coherent sense of self, typically altered in schizophrenia, is accompanied by a coherent ability to integrate sensory information. According to the idea of a psychosis continuum, high schizotypal traits in the general population may be associated to higher proneness to multisensory illusions, akin to schizophrenia. We directly tested this hypothesis by means of the double-flash illusion in participants with low and high schizotypal scores. We confirmed the higher proneness to illusions in the high-schizotypal group. Crucially, such higher proneness was fully explained by a significantly reduced temporal sensitivity to integrate sensory information. We conclude that reduced temporal sensitivity accounts for enhanced proneness to illusions in people at higher risk and represents an early marker of psychosis.

1. Introduction

The development of abilities to integrate sensory input from different modalities into coherent percepts is intertwined with the emergence of a sense of self (Bremner, Lewkowicz, & Spence, 2012; Rochat, 2011). Consistently, multisensory temporal processing abnormalities that extend beyond those observed in the unisensory domains have been shown in schizophrenia (Stevenson et al., 2017), where multisensory deficits are thought to contribute to incoherent self-experiences (Postmes et al., 2014) and perception of the world (Tseng et al., 2015). Within this theoretical framework, the working hypothesis is that attempts to restore perceptual coherence may induce hallucinations and delusions (Postmes et al., 2014).

Multisensory integration deficits in schizophrenia have been commonly investigated using audiovisual illusion tasks, such as the streaming-bouncing illusion (Zvyagintsev, Parisi, & Mathiak, 2017), the McGurk illusion (Martin, Giersch, Huron, & van Wassenhove, 2013) and the double-flash illusion (DFI) (Haß et al., 2017). All these illusions are determined by the brain's effort to bind information from different sensory modalities to create coherent unified precepts. Given the characteristics of the stimuli presented, such percepts (the illusory outcome) are often inconsistent with the actual sensory input. Basically, these sensory illusions can be determined by specific temporal constraints between the senses. Such constraints provide a contextual framework for interpreting ambiguous (e.g. the precise co-occurrence of certain audio-visual events in the streaming-bouncing illusion) or otherwise incoherent stimuli (e.g. the inconsistent correspondence between lip movements associated with a compatible but mismatched sound in the McGurk illusion; or the number and temporal disparity between low-level audio-visual events in the DFI). Despite non-veridical in

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nature, these multisensory illusions reflect robust and peculiar constraints of multisensory integration processes and as such have been commonly used to investigate if multimodal processing is intact, or not, in non-clinical and clinical conditions.

The aforementioned, and other studies have consistently suggested that exaggerated proneness to audiovisual illusions in schizophrenia is coupled to a reduced temporal sensitivity, indexed by a prolonged temporal window in which the illusion is maximally perceived, namely the Temporal Window of Illusion (TWI; (Cecere, Rees, & Romei, 2015)). TWI therefore represents an inverse index for temporal sensitivity (i.e. enlarged TWI = reduced temporal sensitivity). More generally, the temporal window within which the proximal presentation of stimuli from different senses tends to be integrated, rather than segregated, seems to be enlarged in schizophrenia (Stevenson et al., 2017) and, most interestingly, already in high-schizotypy individuals (Ferri et al., 2017). Whether high-schizotypy individuals also experience greater susceptibility to the multisensory illusions is currently unknown; if this would be the case, whether this phenomenon may be fully accounted for by a more general temporal sensitivity mechanism during sensory processing remains another relevant open question to be addressed.

According to a dimensional approach to schizophrenia, schizotypy represents a continuum throughout the general population ranging from psychologically healthy individuals (low-schizotypy) to psychosis-prone individuals (high-schizotypy) (Kwapil & Barrantes-Vidal, 2015; Nelson, Seal, Pantelis, & Phillips, 2013). Notably, psychosis-proneness does not necessarily imply psychosis-risk, and most schizotypes are not expected to develop psychosis. However, substantial overlaps between schizotypy and schizophrenia have been found not only in terms of etiological factors - at the genetic, biological, and psychosocial levels (Barrantes-Vidal, Grant, & Kwapil, 2015) – but also concerning a wide range of perceptual, cognitive, and motor impairments (Ettinger et al., 2015).

The study of perceptual and multisensory integration dysfunction in schizotypy, as compared to schizophrenia, offers the advantage of preventing the psychological variables from being confounded by compensatory strategies, severity, distress, comorbidity, and therapy. Moreover, use of the same experimental paradigms in schizotypy and schizophrenia may contribute to, first, further detailing the idea of a “continuum” between the two conditions (Ettinger et al., 2015); second, to identifying early risk markers.

The aim of this study is to investigate the susceptibility to auditory-induced visual illusions in individuals with high and low schizotypy by means of the DFI, which has been already proven to be informative in people with schizophrenia (Haß et al., 2017). We specifically chose to test very brief audiovisual stimuli as they have the adequate temporal resolution to assess the fine-grained temporal profile of crossmodal interactions (e.g (Murray et al., 2016; Romei, Gross, & Thut, 2012; Romei, Murray, Merabet, & Thut, 2007) and its alterations (Bao, Doobay, Mottron, Collignon, & Bertone, 2017; Haß et al., 2017; Noel, De Niear, Stevenson, Alais, & Wallace, 2017; Stevenson et al., 2017; Stevenson et al., 2014). Specifically, we hypothesize that by comparing the proneness to the DFI between low- and high-schizotypal groups, higher percentage of perceived illusion in the high-schizotypal group is expected. Importantly, according to Ferri et al. (Ferri et al., 2017) we expect that the enhanced percentage of illusory precepts in the high-schizotypal group will be accounted for by an enlarged TWI in this group relative to the low-schizotypal group.

2. Materials and methods

2.1. Participants

One hundred ninety-six adult volunteers, recruited via mailing lists at the University of Essex, were screened with respect to schizotypal traits using the Schizotypal Personality Questionnaire (SPQ; (Raine, 1991)). The questionnaire was administered electronically via Qualtrics, a web-based data collection system. The distribution of scores was divided into quintiles, with the first quintile representing the participants rated as low schizotypes (score range 5–16, n = 32), and the fifth quintile representing the participants rated as high schizotypes (score range 36–68, n = 32). As a result, a total of sixty-four participants falling within the first and fifth quintile were selected to perform the DFI task (Cecere et al., 2015; Shams, Kamitani, & Shimojo, 2000, 2002). All the participants included in the “low schizotypes” and the “high schizotypes” groups had normal or corrected vision, and normal hearing. They did not report history of substance abuse or other (neuro)psychiatric disorders. Age and gender were matched across groups. Demographic details are reported in Table 1.

Performance of three participants in the first quintile and four participants in the fifth quintile did not fit the sigmoid function (see data analysis below), mostly due to unreliable report of the illusion (as a function of the time interval between the two sounds) and were excluded from the analysis. Therefore, a total of fifty-seven participants (29 in the low- and 28 in the high-schizotypal group) were included in the current analyses. The participants gave written consent before taking part in the experiment and all were naïve to the actual purpose of the study.

Table 1
Demographics.

	Low schizotypes	High schizotypes
SPQ score range	5–16	36–68
N	32	32
No of females	25	25
Mean age(SD)	29(9)	26(7)
British White	41%	44%
Other White	50%	50%
Asian/Indian	9%	6%