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Neural correlates of creative thinking and schizotypy

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ABSTRACT

Empirical studies indicate a link between creativity and schizotypal personality traits, where individuals who score highly on schizotypy measures also display greater levels of creative behaviour. However, the exact nature of this relationship is not yet clear, with only a few studies examining this association using neuroimaging methods. In the present study, the neural substrates of creative thinking were assessed with a drawing task paradigm in healthy individuals using fMRI. These regions were then statistically correlated with the participants' level of schizotypy as measured by the Oxford–Liverpool Inventory of Feelings and Experiences (O-LIFE), which is a questionnaire consisting of four dimensions. Neural activations associated with the creativity task were observed in bilateral inferior temporal gyri, left insula, left parietal lobule, right angular gyrus, as well as regions in the prefrontal cortex. This widespread pattern of activation suggests that creative thinking utilises multiple neurocognitive networks, with creative production being the result of collaboration between these regions. Furthermore, the correlational analyses found the Unusual Experiences factor of the O-LIFE to be the most common dimension associated with these areas, followed by the Impulsive Nonconformity dimension. These correlations were negative, indicating that individuals who scored the highest in these factors displayed the least amount of activation when performing the creative task. This is in line with the idea that 'less is more' for creativity, where the deactivation of specific cortical areas may facilitate creativity. Thus, these findings contribute to the evidence of a common neural basis between creativity and schizotypy.

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1. Introduction

Although the exact relationship between creativity and psychopathology is still a contentious issue, there seems to be some consensus regarding a putative link between creative behaviour and mental illness. Anecdotal evidence of artists who suffered from depressive episodes, hallucinations, or drug abuse has led way to empirical studies which indicate a quantitative link between atypical cognition and elevated levels of creativity (e.g., Andreasen, 1987; Becker, 2001; Nettle, 2001; Post, 1994; Richards et al., 1988). However, full-blown psychosis is detrimental to any creative process, leading to the suggestion that this relationship between creative thinking and psychosis lies on an inverted U curve, where the level of creativity rises with certain traits of mental illness but then decreases with the onset of clinical psychopathology (Nettle, 2006). This is in line with the finding of creative achievement in non-affected relatives of patients (Nettle, 2006; O'Reilly et al., 2001). They often share certain traits and predispositions with the affected relative, but have a lower loading of these characteristics which may contribute to the development of creativity without the debilitating effects of psychosis. Thus far, research has shown that these psychologically healthy relatives often show higher levels of schizotypal personality traits compared to the general population, as well as increased creative performance (Fisher et al., 2004; Kinney et al., 2001; Schuldberg, 1990). Therefore, investigating the role of schizotypal personality (or schizotypy) on creative behaviour may provide insight into both behavioural and cognitive correlates of creativity.

Schizotypy is defined as a cluster of subclinical symptoms and personality traits within a healthy population, which are qualitatively similar to schizophrenia symptoms but less severe (Claridge, 1997). The development of this construct derives from observations of individuals who display schizophrenic-like thought patterns and symptoms without the presence of psychosis (Lenzenweger, 2006). Similar to schizophrenia, schizotypy is a heterogeneous construct which can be divided into two broad factors: positive schizotypy, which describes unusual perceptual experiences, delusional thoughts and hallucinations; and negative schizotypy, which encompasses physical and social anhedonia as well as high introversion (Arndt et al., 1991; Holt et al., 2008). Furthermore, it can also include traits such as disorganised cognition and thoughts, and impulsive behaviour. The level of schizotypy can be measured using psychometric questionnaires such as the Oxford–Liverpool Inventory of Feelings and Experiences (O-LIFE;

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Mason et al., 1995), which loads schizotypy onto four factors: unusual experiences; cognitive disorganisation; introvertive anhedonia; and impulsive nonconformity.

A possible overlapping aspect of psychosis and creativity is overinclusive thinking, where the individual is unable to establish conceptual boundaries (Barrantes-Vidal, 2004; Ottemiller et al., 2014). This is also observed in schizotypy research, where divergent thinking (DT) is often used as a proxy measure of creativity. DT is considered to be the useful equivalent of overinclusive thinking, and refers to the capacity of an individual to generate multiple alternative solutions to an open-ended problem (Plucker and Renzulli, 1999). It is thought that there is a greater spread of cortical activation through semantic networks in DT, leading to the activation of indirectly related associations and resulting in enhanced creative thinking (Pizzagalli et al., 2001). Although it is not a direct measurement of creativity and can only provide a useful estimate (for a review, see Runco and Acar, 2012), DT has been widely and consistently employed in the literature as the best method to predict creative potential (Runco, 1991).

Besides DT, another important indicator of creative performance is individual personality traits. There is consensus amongst researchers that extracognitive factors are crucial for creativity research, and studies have shown that personality makes a significant contribution to creativity (for a review, see Batey and Furnham, 2006). Both Eysenck's *P* factor (psychoticism; Eysenck et al., 1985) and *O* and *E* factors (openness to experience; extroversion; Costa and McCrae, 1992) from the Big Five have been implicated in enhanced DT, suggesting that individuals who think unusual thoughts, make uncommon associations, tolerate ambiguity, seek out uncertainty, and are impulsive may be particularly suited to creative endeavours (John et al., 1991; Sanchez-Ruiz et al., 2011; Upmanyu et al., 1996). Many of these personality traits are often observed in individuals who score highly on psychometric schizotypy measures, supporting the idea that common mental processes are involved in both creative thinking and psychosis proneness.

A considerable amount of research has shown a positive correlation between creativity and positive schizotypy (e.g., Folley and Park, 2005; Jones et al., 2011; Weinstein and Graves, 2001). This link is reflected in Burch et al. (2006), who compared the level of schizotypy between visual artists and non-artists and found a significantly higher level of unusual experiences in the artists. Paranormal experiences were also found to be linked to artistic creativity (Kennedy and Kanthamani, 1995), and Nettle (2006) also found that poets and artists displayed higher levels of schizotypal traits compared to controls, especially in the unusual experiences factor of the O-LIFE.

Similarly, Eysenck (1993) suggested that unusual thought processes observed in schizotypy may be due to a lack of cognitive inhibition where highly schizotypal individuals inhibit fewer thoughts during early processing, allowing them to use an increased amount of information in a creative manner. However, the evidence for a link between impaired cognitive control and creativity is less clear, with disorganised thinking being linked both positively (O'Reilly et al., 2001) and negatively (Batey and Furnham, 2008) with creativity. The delivery of the unusual or novel associations in psychometrically measured creative tests may be further aided by an increased inclination to give socially undesirable responses, which may be driven by the impulsive nonconformity dimension of schizotypy (Burch et al., 2006). However, research into these factors are limited, possibly due to the fact that there is less of a consensus between psychometric schizotypal measures when examining factors which are neither strictly positive nor negative.

Literature regarding the relationship between creativity and negative schizotypy is also mixed. Most studies show decreased levels of creativity in individuals who score highly on negative schizotypy subscales (Batey and Furnham, 2009; Tsakanikos and Claridge, 2005), indicating that the avoidance of social interaction and engagement is detrimental to creative thought, possibly by being disengaged with the task. Nettle (2006) also found the lowest scores in introvertive anhedonia within his sample of professional poets and visual artists compared to both psychiatric patients and controls, indicating that the lack of anhedonia and avolition may contribute to artistic creativity. On the other hand, he also observed that mathematical ability (a subset of scientific creativity) was correlated with this negative dimension (Nettle, 2006), and Cox and Leon (1999) also found a positive association between DT and social anhedonia.

In summary, a large amount of behavioural research indicates a link between schizotypal personality and enhanced creative ability. Although there are numerous studies reporting that schizotypal individuals show atypical performance on behavioural tasks such as the Stroop (Mohanty et al., 2005), irony comprehension (Rapp et al., 2010), verbal fluency (Hori et al., 2008), and self-reflection (Modinos et al., 2011), studies investigating this relationship from a neuroscience perspective are comparatively limited. Results from these few studies also support the evidence of atypical cortical activation in creative individuals with high schizotypy: a study using near-infrared optical imaging found that, in addition to enhanced DT ability, schizotypal individuals showed hyperactivation of the right prefrontal cortex during the task when compared to both control and schizophrenia groups (Folley and Park, 2005). The authors suggested that this result could be due to the schizotypal participants being able to use their unusual thoughts in a creative rather than dysfunctional manner, and that the right PFC may have a role in this difference of cognitive output.

A functional magnetic resonance imaging (fMRI) study has also shown reduced deactivation in the right precuneus in individuals scoring high on a schizotypy scale when performing a creativity task, compared to low-scoring individuals who, in turn, displayed a strong deactivation of the same region (Fink et al., 2014). Furthermore, Fink et al. (2014) found that the pattern of brain activity during creative thinking was similar for both the high schizotypy and high creativity groups, suggesting that common cognitive processes may be involved in both creative thinking and psychosis proneness. Structural studies have also shown a possible link between brain structure, creativity, and psychopathology, where reduced white matter integrity (measured by fractional anisotropy) was found in similar cortical areas for schizophrenia and bipolar patients, and also with healthy participants scoring high in DT (Jung et al., 2010a; Sussman et al., 2009).

Nonetheless, apart from the two functional studies mentioned above, there is a lack of direct neuroimaging evidence for the brain mechanisms underlying creative thinking in schizotypal individuals. Therefore, the main objective of this study was to address this gap by using fMRI to examine whether the neural processes stemming from creative thought can be directly correlated to specific dimensions of schizotypy. We were also interested in the neural correlates of both figural/artistic creativity and verbal creativity, as the majority of research has focused on verbal creativity tasks. Thus far, neuroimaging evidence for verbal creativity (regardless of schizotypy) has been inconsistent, with some showing increased left hemispheric activation (e.g., Bekhtereva et al., 2004), and others showing greater involvement of the right hemisphere (e.g., Jung-Beeman et al., 2004). Such mixed findings have been attributed to the different types of verbal tasks used, as well as the activation of possibly more complicated neural networks stemming from the linguistic processing component of the tasks (Kowatari et al., 2009). Therefore, we decided to employ both figural and verbal creativity behavioural measures in order to establish potential behavioural and neural differences in our sample.

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