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The interaction of Matrix Reasoning and Social Motivation as predictors of Separation anxiety in boys with Autism Spectrum Disorder

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ABSTRACT

Background: It has been suggested that higher cognitive functioning based in the pre-frontal cortex is implicated in the ability of people with Autism Spectrum Disorder (ASD) to understand and communicate in social situations. Low motivation to engage in social interaction may also be influential in this process. Although both of these factors have been argued to influence the levels of comorbid anxiety in young people with ASD, no detailed examination of those relationships has been reported to date.

Methods: A sample of 90 boys with ASD (aged 6 to 12 yr) and 29 of their non-ASD peers, matched for age and IQ, completed tests of cognitive function and anxiety.

Results: Only one form of anxiety—fear of being separated from their parents– was significantly associated with cognitive function, at the Full Scale IQ and Matrix Reasoning levels, plus motivation to engage in social interactions, and only for the ASD boys.

Conclusion: These data represent a complex interaction between the neurobiological aspects of ASD, fluid reasoning, social motivation, and Separation Anxiety in boys with ASD. As such, they bring a new perspective to understanding and treating anxious behaviour in these boys.

1. Introduction

1.1. Autism Spectrum Disorder and the prefrontal cortex

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition marked by difficulties in social communication and interaction, and repetitive and restrictive behaviours (APA, 2013). Several models have been suggested to explain the neurobiological bases of ASD, including early enlargement of the amygdala (Sparks et al., 2002), accelerated brain growth during the first year of life, followed by a plateau (Courchesne et al., 2011; Redcay and Courchesne, 2005) and reduced neural connectivity (Swartz et al., 2013), among others. Although none of these models has been without controversy, a recent meta-analysis of 88 imaging studies of persons with ASD and Obsessive-Compulsive Disorder (OCD) concluded that both groups showed reduced structure and function in the prefrontal cortex (PFC) (Carlisi et al., 2017), perhaps accounting for the presence of restricted and repetitive behaviours in ASD (similar to those exhibited by persons with OCD) and providing some focus upon the role of the PFC in that aspect of ASD symptomatology. Previous research has also shown that enlargements in gray and white matter in the PFC of 'children with ASD (Palmen et al., 2005) led to reduced connectivity between the PFC and other regions (Ha et al., 2015). That reduced connectivity was significantly associated with an inability to evaluate information about social interactions (Hoffman et al., 2015), the other major diagnostic criteria for ASD (APA, 2013). Further support for the role of the PFC in this aspect of ASD symptomatology came from a clinical trial of oxytocin-induced increase in PFC activity, which was paralleled by improvements in social communication abilities (Watanabe et al., 2014).

In the general population, PFC functions include a number of cognitive and emotional faculties that develop throughout childhood and adolescence, and include a movement from concrete thinking to being able to understand constructs and stimuli from an abstract perspective (Dumontheil, 2014; Klenberg et al., 2001), often measured via select aspects of IQ testing. As well as these general developmental changes during childhood, another aspect of PFC functioning is the individual's growing ability to manage their own emotions and to recognise emotions in others (Kolb et al., 1992; Magis-Weinberg et al., 2017). These processes develop so that the social brain and the relational reasoning network run in parallel to integrate social information in adolescence

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and adulthood. However, these may be only at a stage of partial functioning during childhood (Magis-Weinberg et al., 2017), and the developmental nature of PFC functions is reflected in the gradual move from childhood fear disorders such as Separation Anxiety, to those more likely to occur during adolescence, such as Social Anxiety (APA, 2013). It has been suggested that these maturational processes rely upon the development of abstract reasoning skills (Rosso et al., 2004) and may be measured by indices of nonverbal reasoning, fluid reasoning, induction, ability to form analogies, and concentration (Sattler, 2008). One index of these cognitive functions is described as Matrix Reasoning.

1.2. Matrix Reasoning, Social Motivation, and Anxiety

Tests of Matrix Reasoning usually consist of a series of coloured matrices or pictures with something missing from the last matrix or picture. The test participant is asked to choose from a group of possible of alternatives to complete the missing matrix/picture. That choice is based upon an understanding of the relationships between the previous matrices or pictures in the series and then predicting what the next (missing) matrix/picture should look like. This process is untimed, so the test-taker may reflect upon their choice before making it. Matrix Reasoning tests are a fair measure of *g*, or fluid intelligence (Sattler, 2008) and may be used to measure the cognitive functions of nonverbal fluid reasoning, induction, reasoning ability, and ability to form analogies (Sattler, 2008). Many of these cognitive skills are involved in understanding complex social situations and deciding how to interact in such situations. The high degree of difficulty that people with ASD have in social interaction and communication (one of the key diagnostic criteria for ASD) may be influenced by their restricted ability to draw inferences about social interactions from the observations they make of social situations, i.e., their ability to form analogies, induct plausible responses, and draw reasoned conclusions from the observations they make about the ways that people interact. Thus, a hypothetical association may be posited between Matrix Reasoning and understanding and reacting to new social situations. It is relevant to also note that scores on tests of Matrix Reasoning are affected by "motivation and persistence" and "a willingness to respond when uncertain" (Sattler, 2008, p. 340). That is, while the reduced PFC functioning that has been previously reported in children with ASD may act to restrict their ability to understand and react to social situations (APA, 2013), this restricted ability to cope with social situations might also be influenced by their motivation to persist in those tasks of understanding and reacting to social situations.

There has been some disagreement regarding whether young people with ASD are motivated to engage socially with others. For example, some suggestions have been made that the difficulties that people with ASD experience in social interaction and communication are the result of low intrinsic motivation to engage in social situations (Chevallier et al., 2012a,b). Other research has disputed that model, finding that children with ASD expressed a desire to approach others (Deckers et al., 2014). A third model has suggested that social motivation in autistic people is context dependent, supported by data showing that adolescents and adults with ASD demonstrated a motivation to engage socially with family members and other close friends rather than with people who were not so well known to them (Chen et al., 2015). It may be that this preference for engaging socially with well-known others may be related to the degree of anxiety the person with ASD experiences about that engagement, which may be elevated when strangers are encountered, but lower when very familiar family members are the target of social interaction.

1.3. Anxiety (and its measurement) in ASD

Research has consistently reported elevated levels of anxiety in children with ASD compared to non-ASD children (Kim et al., 2000; White et al., 2009), including Generalised Anxiety Disorder (GAD), Social Anxiety, and Separation Anxiety, but with some changes over time in the relative prevalence of these different forms of anxiety. For example, Kim et al. (2000) found that GAD occurred at a rate of 13.6%, followed by Separation Anxiety (8.5%) in their sample of 112 children with an ASD aged between 9 and 12 years but, in an older sample aged 10–14 years, Simonoff et al. (2008) found that Social Anxiety was most common (29.2%), followed by GAD (13.4%). It may be that these changes in the form of anxiety reflect the maturational changes in abstract reasoning processes within the PFC discussed above.

However, the papers reviewed by Kim et al. (2000) and Simonoff et al. (2008) relied upon parental reports of their child's anxiety. As noted by van Steensel et al. (2011), who performed a meta-analysis of 31 studies of anxiety on 2121 young people with ASD aged under 18 years, "studies were heavily dominated by parent reports" (p. 307). While not necessarily a weakness in research methodology, it has been noted by the authors of one review that there are only modest levels of agreement between parents' assessment of their children's anxiety and the children's self-reports of their anxiety, and that it is not possible to "effectively capture" (p. 213) the actual state of child anxiety from parental reports alone (Achenbach et al., 1987). Another review indicated that parents tended to report more symptoms of dysfunction about their children when the latter were drawn from a clinical population than a non-clinical population (Montgomery, 2008), potentially biasing data collected from the parents of children with ASD. As a demonstration of the value of obtaining assessments of a child with ASD's anxiety from the child themselves, the self-ratings provided by a sample of children with ASD aged 6–17 years were significantly correlated with their HPA axis responses to chronic stress (i.e., elevated morning cortisol) but their parents' evaluations of their children's anxiety were not similarly correlated with these HPA axis responses, using the same scale and collected at the same time (Bitsika et al., 2014).

2. Aims of the study

Therefore, this study explored the association between PFC functioning (as assessed by an index of Matrix Reasoning), social motivation, and self-rated anxiety (specifically GAD, Social Anxiety, and Separation Anxiety) in a sample of children with ASD. The aims of the study were to (i) identify any such associations, (ii) compare the relative strength of the associations between Matrix Reasoning versus social motivation with GAD, Social Anxiety, and Separation Anxiety, (iii) to identify the specific aspects of these three forms of anxiety for their association with Matrix Reasoning and social motivation by examining any significant associations at the level of individual item/symptoms as well as total scores, and (iv) to compare these findings for Matrix Reasoning and anxiety with a non-ASD sample matched for age and IQ. Because ASD is predominantly diagnosed in males (APA, 2013), the samples were restricted to males only. Similarly, because the focus of this investigation was children rather than adolescents, the participants were between 6 yr and 12 yr of age.

3. Methods

3.1. Participants

Boys with ASD. The ASD sample consisted of 90 boys with diagnosed ASD and one of their parents (12 fathers, 78 mothers). The boys were aged between 6yr and 12yr (M age = 8.8yr, SD = 1.9yr). All these ASD boys and their parents were recruited from parent support groups and other service organisations in Queensland, Australia, and all parents provided written informed consent to participate; their sons gave verbal assent to participate. Over 97% of the sample had been born in Australia and all were Anglo-Saxon in ethnicity. The original diagnoses for these boys had been performed several years prior to this study, and were confirmed by administration of the Autism Diagnostic Observation Schedule (ADOS) (Lord et al., 2012) by a research-reliable