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Exploring different explanations for performance on a theory of mind task in Williams syndrome and autism using eye movements

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ABSTRACT

The current study explored the looking behaviours of young children with Autism Spectrum Disorders (ASD), Williams syndrome (WS), and typically developing (TD) children while they were administered a low-verbal Theory of Mind (ToM) task. Although ToM performance in both clinical groups was impaired, only participants with WS showed small differences in looking behaviour at the start of the video. Furthermore, while TD children who passed the ToM task looked longer at the original hiding place there was no such contrast in the clinical groups. This shows that looking behaviour in ASD and WS is not necessarily atypical when saliency aspects such as language, background, and colour are removed and that differences in looking behaviour cannot explain ToM performance.

1. Introduction

It is now well established that Theory of Mind (ToM) ability forms a platform for the development of socio-cognitive abilities, such as understanding of the intentions and behaviour of others (Premack & Woodruff, 1978). The nature and theoretical interpretation of ToM has become a focus in developmental and neurocognitive research and has sparked a wide range of paradigms. Studies have shown a clear progression on the acquisition of ToM abilities with typically developing (TD) children aged 4 years and younger passing simple ToM tasks (Liszkowski, Albrecht, Carpenter, & Tomasello, 2008; Wimmer & Perner, 1983), while more complex ToM abilities continue to develop into adulthood (Apperly, Warren, Andrews, Grant, & Todd, 2011). In contrast, individuals with developmental disorders, such as Autism Spectrum Disorders (ASD) and Williams syndrome (WS), have been found to be impaired on ToM tests, even when their mental age exceeds that of a 4 year old (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997; Tager-Flusberg & Sullivan, 2000).

WS is a rare neurodevelopmental disorder (about 1 in 20,000 live births) caused by a deletion of some 28 genes on the long arm of one copy of chromosome 7 at q11.23 (Donnai & Karmiloff-Smith, 2000). Despite an overall lower IQ of 50–70, individuals with WS show an uneven cognitive profile, with good performance on receptive vocabulary and face recognition in contrast to non-verbal abilities such as number, planning, visuo-spatial abilities, and route learning (Van Herwegen, Rundblad, Davelaar, & Annaz, 2011). Although individuals with WS are inclined to be overly sociable (Mervis et al., 2000), their performance on tasks that assess cognitive aspects of social development is impaired. This has led researchers to

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conclude that the social profile in WS might be uneven as well with the social perceptual components being intact but the socio-perceptual component being impaired (Tager-Flusberg & Sullivan, 2000). However, more recent studies have found that participants with WS also show difficulties on tasks that tap into socio-perceptual abilities (for example Plesa-Skwerer et al., 2006).

In contrast, Autism Spectrum Disorder (ASD) is a common neurodevelopmental syndrome (1 in 100) characterised by two core impairments in communication or social behaviour and repetitive behaviours from early childhood onwards (*The Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; *DSM-5*; American Psychological Association, 2013). While there are marked individual differences in the extent and quality of the symptoms amongst individuals with ASD, one of the most common features is a striking difficulty with social skills, including the ability to attend to faces and difficulties in emotion recognition (Klin, Jones, Schlutz, Volkmar, & Cohen, 2002; Riby, Doherty-Sneddon, & Bruce, 2011). However, not all studies have found that individuals with ASD have an aversion towards faces and atypical looking behaviour towards faces and impaired emotion recognition has been found for static stimuli but not always for dynamic stimuli (Back, Ropar, & Mitchell, 2007; Speer, Cook, McMahon, & Clark, 2007).

Although there are many contrasting features between the individuals with ASD and WS, there are also several commonalities in their behavioural and cognitive profiles (Lincoln, Searcy, Jones, & Lord, 2007). For instance, both groups show socio-communication problems such as delayed use of pointing, unusual eye contact and problems with joint attention (Charman et al., 1997; Klein-Tasman, Mervis, Lord, & Phillips, 2007; Laing et al., 2002). In addition, impairment on ToM tasks has been reported in both clinical groups. For example, Baron-Cohen, Leslie, & Frith (1985) reported that 80% of individuals with autism failed the change-of-location task Sally-Ann in which participants are asked to follow a scenario where Sally leaves a marble in a basket and Ann moves the marble to a box while Sally is away. Individuals with ASD responded incorrectly to the false-belief question of the Sally-Ann task by answering that Sally should look in the box where the marble had moved to rather than in the box Sally believed the marble to be in. Similarly, participants with WS fail this task as well (Tager-Flusberg & Sullivan, 2000; Van Herwegen, Dimitriou, & Rundblad, 2013). Because of the differences and similarities in their social and cognitive profiles, contrasting performance of individuals with ASD to WS allows us to explore the cognitive mechanisms that underlie task performance, including theory of mind tasks.

Several domain specific theories have been proposed as to why individuals with ASD and WS might fail ToM tasks: for example performance on ToM tasks might be caused by the language impairments observed in WS and ASD (Happé, 1995; Tager-Flusberg, 2000). Yet, others suggest executive functioning and the use of context, are better predictors (Pellicano, 2010; Van Herwegen et al., 2013). Although several studies have shown evidence for a deficit to use context in WS and ASD (for a review see Bernardino et al., 2012 as well as Happé & Frith, 2006), studies in ASD have shown that this cannot explain performance on ToM tasks (Burnette et al., 2005; Happé, 1997).

One reason why the current theories cannot describe the difficulties observed in ASD and WS is that they only focus on domain-specific areas of cognition to explain ToM deficits. Recent evidence has suggested that impairments in domain-general abilities, such as attention or where in a visual scene a person was looking for detailed information, can explain impairments in domain-specific areas later on in life (Karmiloff-Smith et al., 2012). Thus, it is possible that subtle differences in looking behaviour or where a person was looking for detailed information can provide valuable information about what strategies individuals use to complete a task and whether task approach in WS and ASD is typical or atypical which in turn might provide an explanation for the task performance in ASD and WS on ToM tasks.

Previous eye tracking studies in participants with WS and ASD have shown that they show atypical attention patterns during social tasks. Riby and Hancock (2009) found that in human videos individuals with WS aged 8–28 years old spend more time looking at faces and less at the actors' bodies compared to controls while participants with ASD of a similar age looked less at the faces compared to the controls. It has been suggested that these atypical looking behaviours are related to the social abilities of individuals with WS and ASD and that atypical attentional bias towards others' faces could contribute to atypical social orienting (Kikuchi, Senju, Tojo, Osanai, & Hasegawa, 2009). For example, Klin et al. (2002) showed that adolescents with ASD focussed more on the mouth and less on the eye region while watching black and white video clips from the film "who is afraid of Virginia Woolf", in contrast to TD controls. They also found that looking behaviour predicted social competence in ASD: those who spend longer fixating on the mouth were more sociable, while there was a negative correlation for sociability and the time fixating objects. This suggests that atypical looking behaviours might also cause problems for task performance on theory of mind tasks (see also, Senju et al., 2010). However, none of these studies have directly examined whether individuals with WS and ASD show atypical looking behaviour during a ToM task and whether these looking behaviours can actually explain ToM deficits.

The current study is the first to explore the looking behaviours of participants with ASD and WS whilst performing a ToM task. Based upon previous studies, it was hypothesised that those with WS would fail the test questions as they would have difficulty to disengage from social stimuli which would prevent them from focusing on where the object had been hidden as well as where the object had been moved to. In contrast, those with ASD would fail the task as they would favour non-social stimuli in the background and thus they would have insufficient information to infer the deception included in the ToM task, as information about deception is especially visible in facial expressions. Thus, for both developmental disorders it was predicted that atypical looking behaviour would impair their focus on important information in the scene resulting in incorrect cognitive interpretations about the outcome of the ToM situation.