Exploring Theory of Mind and Visual and Spatial Working Memory in Typically Developing Adults with High Levels of Autistic Traits

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Dissertation submitted in partial fulfilment of the requirements of Cardiff Metropolitan University for the degree of Bachelor of Science
DECLARATION

I hereby declare that this dissertation is the result of my own independent investigation under the supervision of my tutor. The various sources to which I am indebted are clearly indicated. This dissertation has not been accepted in substance for any other degree, and is not being submitted concurrently for any other degree.
Acknowledgments

Firstly, I would like to take this opportunity to thank my supervisor, [Name], for all of his constant support and guidance over this past year. It truly means a lot. I would also like to thank [Name] for his patience helping to set up my materials on my laptop.

Secondly, I would also like to thank my mum for her continuous support and encouragement throughout my time at university, and trying to uplift me through my numerous breakdowns. I am truly grateful.

I would finally like to thank my friends [Names] for all their support, reassurance and our unforgettable memories made at university, and [Name] for her endless supply of coffee.
Abstract

Autistic Spectrum Disorder (ASD) is one of the most common diagnosis given across the UK and is characterised as having profound difficulties within a person’s social interaction and executive control. Although links between theory of mind and autism have been often investigated in those with autism, little research has been conducted on a subclinical level. The present study was carried out with the aim of discovering whether theory of mind, verbal and spatial working memory can predict levels of autistic traits within typically developing adults. Through conduction of two multiple regression analyses the main findings support the notion that theory of mind can be used to negatively predict levels of autistic traits. It was also found that spatial working memory is a high negative predictor of theory of mind, whereas verbal working memory had little predictive value. This suggests that spatial working memory can indirectly be used to predict levels of autistic traits.

“Did I gradgitate this time yet” – Tall Morty – Rick and Morty 2017
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1.0 Introduction

1.1 – Background of Autism Spectrum disorder

Autism spectrum disorder (ASD) is a developmental disorder which is diagnosed based on early onset of emerging social and communication impairments (Frith & Happe, 2005), these symptoms need to be to the extent of limiting or impairing their everyday functioning (DSM-5). ASD has been characterised as having a profound impairment in social interaction and communication (DSM-5), as well as having repetitive behaviours and restricted interests (American Psychiatric Association, 2013; Hill, 2014). It has been found that individuals with ASD display clear deficits in their ability to infer another person’s mental state (Gokcen, Frederickson, Petrides, 2016), show no emotional reaction when observing another person in pain (Minio-Paluello, Baron-Cohen, Avenanti, Walsh & Aglioti, 2009) and entail reduced attention to faces and decreased eye contact from an early age (Phillips, Baron-Cohen & Rutter, 1992; Osterling, Dawson & Munson, 2002; APA, 2013).

ASD is the most common diagnosis given (APA, 2013) and is one in a group of neurodevelopmental disorders also known as pervasive developmental disorders (PDD). The collective terms part of ASD are; Autism, Asperger syndrome/disorder and Pervasive Developmental Disorder – Not Otherwise Specified (PDD-NOS). ASD is estimated to be present in 0.62% of the total population (Elsabbagh, Divan, Koh, Kim, Kauchali, Yasamy & Marcin, 2012). These pervasive developmental disorders are characterised by three core deficits: impaired communication, impaired reciprocal social interaction and restricted, repetitive and stereotyped patterns of behaviours or interests (Faras, Ateeqi and Tidmarsh, 2010).

1.2 - Autism and Theory of Mind

According to Shamay-Tsoory (2011), there are two components that contribute towards the cognitive deficits in those with ASD; the cognitive components is the deficit in the ability to understand other people’s minds and make inferences about what another person is thinking or feeling, without being able to share their mental state. This is due to the deficits with recognising and interpreting emotional facial expressions as mentioned previously (Baron-Cohen, 1995; Golan, Baron-Cohen, & Hill, 2006; Grelotti, Gauthier, & Schultz, 2002; Klin, Jones, Schultz, Volkmar, & Cohen, 2002a), this is referred to as theory of mind. Theory of mind
is being able to attribute mental states to oneself and to be able to explain another person’s behaviour and why they are behaving in a certain way (Dziobek, Fleck, Kalbe, Rogers, Hassenstab et al., 2006; Frith & Frith, 2005; Goldman, 2012). It is being able to infer a full range of mental states that cause action such as; beliefs, intentions, imagination, emotions and intentions of others (Baron-Cohen, 2001; Ashwin, Chapman, Colle & Baron-Cohen, 2006), as well as understanding that other people have their own plans, thoughts and points of view (Edelson, 1995: 2006; Tager-Flusberg, 2007). The second component is the affective component which relates to the executive function that allows one to experience the feelings of others whilst understanding that they are distinct from one’s own (Frith & Frith, 2003; Premack & Woodruff, 1978; Shamay-Tsoory, 2011).

By having theory of mind, we can recognise that another person’s knowledge is different from our own and allows us to interact appropriately (Frith & Frith, 2006), these difficulties appear to be universal among individuals with autism (Baron-Cohen, 2000). Just as, Gokcen, Fredrickson and Petrides (2016) found that children with autism have a specific problem with theory of mind tasks. Complex problems that involve white lies or double bluff take those with autism longer to learn and understand which results in them never grasping them fully (Frith and Frith, 2005). Ozonoff, Cook, Coon, Dawson, Joseph and Klin (2004) reported that individuals with autism tend to have deficits in executive-functions that require planning, flexibility and working memory, as the performance on false belief tasks completed by both developing children and autistic children significantly relate to aspects of executive control (Joseph & Telger-Flusberg, 2004).

The majority of studies investigating theory of mind in individuals with autism primarily focus on the transition that takes place before the age of four. This perspective reduces complex social-cognition developmental progression, therefore, creating the impression that autism can be defined by the absence of theory of mind (Talger-Flusberg, 2007), however, some studies have shown that some children with autism can in fact pass false beliefs tasks (Steele, Joseph & Tager-Flusberg, 2003).

Through conducting a study using functional Magnetic Resonance Imaging (fMRI), Kana, Maximo, Williams, Keller, Schipul, Cherassky and Just (2015) found that those with autism showed significantly reduced activation in the regions considered to be part of the theory of mind network, such including superior frontal gyrus, angular gyrus and precuneus. Their
functional connectivity analysis revealed under connectivity between frontal and posterior regions of the brain during task performance in those with autism (Kana et al, 2015).

However, it is possible to display certain characteristics of autism without having a clinical diagnosis of ASD, usually referred to as autistic traits (Bolte, Poustka & Constantino, 2008; Baron-Cohen, Wheelwright, skinner, Martin & Clubley, 2001). It has been found that the genetic variants that are present in a large part of the general population, play a role in the ethology of autism (Robinson, Koenen, McCormick, Munir, Hallet, et al., 2011; Anney, Klei, Regan, Conroy & Magalhaes, 2010). Through conducting a twin study within the general population Constantino and Todd (2003) found that parents and other family members of those with autism tend to display a higher level of autistic traits (Constantino & Todd, 2003; Bishop, Richler & Lord, 2006). Therefore, it has been suggested that subclinical autistic traits within family members are influenced with the diagnosing of ASD (Hoekstra, 2010). With regards to theory of mind, Gocken, Petrides, Hudry, Fredrickson and Smillie (2014) reported that those typically developing adults who do display elevated levels of autistic traits, also display poorer theory of mind performance when tested. Just as Lockwood, Bird, Bridge and Viding (2013) who too, found that those with higher levels of autistic traits were more susceptible than the general population to ASD related deficits.

While assessing executive functioning and theory of mind, other studies found that those who exhibit high autistic traits have a consistent link between the two constructs (theory of mind and executive functioning) (Joseph and Tager-Flusberg, 2004; Pellicano, 2007). Those demonstrating higher autistic traits displayed significantly poorer performance on tasks measuring ToM and cognitive flexibility (Gokcen et al, 2016). These deficits in theory of mind provide plausible explanations for the major symptoms of autism, especially impairments in social communication (Tager-Flusberg, 2007).

Using the Wisconsin Card Sorting Task (WCST), Gokcen et al. (2016) found that task performance predicts good performance on the Movie of Assessment Social Cognition (MASC), as well as finding autism is negatively related to MASC and mind behind the EYES performance, the WCST is positively related to performance on the MASC, the Go No Go (GNG) task is negatively related to performance on the MASC, yet the MASC is positively related to the Tower of London (ToL) task, which measures an individual’s planning ability, and autism is positively related to the GNG, which measures inhibition. However, the GNG
task is used to measure impulse control through inhibition (Fillmore & Weafer, 2013). Therefore, doesn’t require processing of any sort and should not be used as a measure for executive control in relation to autism/autistic traits. The WCST is an appropriate measure for executive functioning as it taps into neuropsychological processes such as cognitive flexibility, problem solving and response maintenance (Greve, Love, Sherwin, Mathias, Ramzinski and Levy 2002).

1.3 - Spatial and Verbal Working Memory and Autistic Traits

As well has having deficits within theory of mind, Kercood, Grsovic, Banda and Begeske (2014) found that those who possess elevated levels of autistic traits, score lower on measures of working memory than typical controls, more specifically on tasks that require cognitive flexibility, planning, greater working memory load, and spatial working memory. Working memory is a process by which information is actively maintained for very short periods of time while performing tasks (Baddley, 1986; Williams, Goldstein, Carpenter & Minshew, 2005). It involves abilities to maintain and manipulate information to plan complex responses (Baddley, 1986; Steele, Minshev, Luna & Sweeney, 2007). Williams, Goldstein, Carpenter and Minshev (2005) reported findings that those with autism have intact verbal working memory and impaired spatial working memory and the breakdown that occurs in verbal working memory as information processing demands are increased will likely provide valuable insights into the neural basis of autism (Williams et al, 2005). This dissociation between verbal and spatial working memory may represent a neurobiological difference between the two working memory systems.

Verbal working memory refers to long term representations that supports performance on recall tasks when they occupy the focus of attention, rendering information accessible (Williams et al, 2005). Deficits within spatial working memory have been reported in those with autism through an oculomotor delayed response task (Minshev, Luna & Sweeney, 1999). However, this task involved participants with high functioning autism being presented briefly with a single visual target, and holding that single piece of information overtime. It does not require maintenance of information over multiple trials and does not rely on organisational strategies (Steele et al, 2007). Therefore it is debateable whether the oculomotor delayed response task is a true spatial working memory task rather just a general working memory task.
Using fMRI, Luna, Minshew, Garver, Lazar, Thulborn and Eddy (2002) linked this verbal and spatial working memory deficit to reduced task-related activation in the dorsolateral prefrontal cortex. Other literature has also found that while verbal working memory remains intact and spatial working memory appears to be impaired, it appears to be inconsistent with other findings. Ozonoff and Strayer (2001) who used a spatial memory-span task to recall the location of three to five geometric shapes on a computer screen as well as a box search task, where participants had to search for object hidden behind coloured boxes while holding the colour of the box in working memory during their search. They appeared to have found no significant differences between autistic and controlled participants from the two tasks. Other researchers such as Griffiths, Pennington, Wehner and Rogers (1999) also found no deficits within spatial working memory using tasks that require high functioning autistic individuals to search under boxes to find hidden targets. However, Steele et al (2007) argue that failures to demonstrate spatial working memory in the previously mentioned studies of individuals with autism could be due to the insufficient levels of task difficulty. They argue that those with autism may show working memory deficits only when the working memory load exceeds a threshold beyond their working memory capacity (Minshew et al, 2007).

Although, some studies have shown to be inconsistent with these findings in deficits within spatial working memory in those with autism, as Griffith, Pennington, Wehner and Rogers (1999) reported findings that children with autism and children with developmental delays were both able to remember the location of hidden objects. However, performance of children in both groups were well below typically developing children, suggesting that those with developmental delays and those with autism both have deficits with spatial working memory. However, Steele et al (2007) demonstrated that spatial working memory deficits are evident when the tasks require a higher demand of working memory capacity and argued that those findings that fail to detect working memory deficits may be related to their tasks and the lack of demand they require of working memory. They also found that working memory deficits in autism may exist in both the ability to maintain precise internal representations of spatial location information overtime and the ability to remember global spatial information when the demands of working memory capacity are high (Steele et al, 2007). Their findings suggest that spatial working memory deficits in autism may not involve increased rates of
forgetting information overtime rather than the importance of information that needs to be kept active in working memory overtime.

1.4 - Rationale, Summary and Aims

To summarise, the aim of the present study is to assess autism symptomology amongst typically developing population as it is a promising way forward, potentially offering novel information about the social and non-social features of ASD. Advantages of examining typically developing individuals with ASD traits is that they are more likely to be tolerant of the structured testing environments that those with a clinical diagnosis. Thus, providing a unique insight into the spectrum by employing a wider range of tasks and methodologies when studying the broader population. A number of predictions are made for this study, the first being that theory of mind will significantly predict autistic traits, and the second being that spatial and verbal working memory will have some predictive power over autistic traits. The establishment of these links may have important implications in both clinical and non-clinical ASD (Gokcen et al, 2016), in regards to future treatment techniques, and provide further insight to the core deficits within autism.

The current study will use a newer, more sensitive measure of measuring theory of mind – the MASC-MC. As the Receiver Operating Characteristic (ROC) analysis identified that the MASC discriminates between groups most accurately. Therefore, making is a more sensitive, and reliable method for evaluating mind reading difficulties (Dziobek et al, 2006). Although other video-based instruments have been developed, such as Roeyers, Buyesse, Ponnet and Pichal (2001) video for the Empathetic Accuracy Paradigm, the mental states inferred are narrow in range and are missing complex emotions and classical theory of mind concepts (Dziobel et al, 2006). The MASC allows for a greater measure of control over the mental state modalities with positive, negative and neutral valence that adopts concepts such as false beliefs, metaphors and sarcasm to enable a broad range of mental states to be inferred (Dziobek et al, 2006).
2.0 Method

2.1 Participants

As this study is looking at autism on a sub-clinical level, the criteria needed to exclude those who had already been clinically diagnosed with autism spectrum disorder or Asperger syndrome. There were 49 participants recruited for this study to obtain a variety of scores. All participants were over the age of 18, of mixed gender and had consented to the study. Age and sex of participants were not accounted for. Some participants were recruited through the universities participant panel that was sent out via email. Other participants were recruited via emailing personal contacts of the researcher.

2.2. Design

A correlational design was adopted for the current study. The advantages of using this design allows us to uncover relationships between variables and draw conclusions about their relationships.

This study will conduct two multiple regressions. The first independent variables (IV) are; theory of mind, spatial working memory and verbal working memory and dependent variable (DV) in this study is autistic traits and the independent variables

The second multiple regression will measure theory of mind as the DV and spatial and verbal working memory as the IV’s.

2.3. Materials

Materials used for this study included;

The movie for the assessment of social cognition - multiple choice: MASC-MC (Dziobek et al., 2006) to measure theory of Mind. The MASC-MC is a video based metalizing task that approximates the demands of real-life situations. This task required participants to watch a short video of four characters engaging in social activity and answering multiple choice questions based on the characters feelings or expressions within the social setting. The MASC-MC included questions such as “What is Cliff feeling?” and given the option of four possible answers. After the task, participant’s answers were scored using Dziobek et al (2006) answer sheet. Permission to use this tool was contingent on sharing the data collected from
the current study with those who developed the MASC. To calculate the scores, correct responses were scored as one point and incorrect responses were scored as zero. The correct responses were totalled. Those answers marked as zero where scored + or 0 against a key; exceeding theory of mind (+), no theory of mind (0) and less theory of mind (-). Depending on the participants answer, their scores of zero were added up into each category. The total was then added or taken away from their correct responses. For example, if they scored 30, but had 5 zeros that fell into the exceeding theory of mind category and 7 zeros that fell into the less theory of mind category then scores were calculated as follows: 30 + 5 – 7 =28. Then their overall performance score on this task would be 28. (See appendices).

The Autism-Spectrum Quotient (AQ) self-reporting questionnaire (Baron-Cohen, Wheelwright, Skinner, Martin & Clubley, 2001) was used to measure autistic traits. The AQ contains 50 questions each scored on a 4-point Likert scale. At the end of the questionnaire each participant was given a score that ranged from 0-50. To prevent recruiting people that may have been within a clinical range for diagnosis of autism, participants were excluded if they had an AQ score higher than 32 (Baron-Cohen, 2001). This recruitment procedure has been used in previous studies that have examined cognition and autism traits in the ‘normal population’ (Baron-Cohen, Wheelwright, Hill, Raste & Plumb, 2001; Goken, Frederickson & Petrides, 2016)

Spatial working memory was measured using a computer based rotation span task (Stone and Towse, 2015). Participants were first presented with a random letter that they had to make judgements on whether it was rotated or mirrored. They were then presented with either a large or small arrow pointing in a random direction, that they had to memorise. At the end of each trial they had to recall which arrows they were presented with in serial order. The task then stated whether they had it right or wrong before beginning the next trial. Each trial had an extra arrow on the sequence, making it more difficult for the participant to remember. This task consisted of 18 trials in total, equalling 3 trials per list length up to 7. Starting with 2 spans per trial, increasing by one each time. For example, 2 arrows, 2 rotated letters, 3 times, 3 arrows, 3 rotated letters, 3 times4 arrows, 4 letters, 3 times and so on.

Verbal working memory was measured using the reading span task (Stone and Towse, 2015), which was also presented on a computer. Participants were presented with a number for 2
seconds and then presented with a statement (e.g. Ducks wear tennis shoes) and had to determine whether it made sense or no-sense. They were then told to recall the numbers presented to them in serial order before the next trial started. Again, each sequence expanded by one after each 3 sets. For example, 2 statements, 2 numbers, 3 times then recall; 3 statements, 3 numbers, 3 times then recall and so on.

2.4. Procedure

Ethical approval was granted on 8/3/2018 by the Cardiff Metropolitan University ethics panel. Some participants were recruited through the Cardiff metropolitan university’s participant panel whereby they signed up, providing they met the criteria. Those recruited externally from the university, were recruited verbally through personal contacts of the researcher. All participants were allocated different time slots. When they arrived each participant was given time to read over an information sheet which included their right to withdraw at a certain time, written consent was then given by the participants before completing the series of tasks. Before the tasks were carried out, each participant was briefed on what was required of them and asked if they had any questions or concerns.

Once happy and ready to proceed, participants were seated in a controlled environment, where by no external factors could influence or interrupt their decision making or answers. Participants were required to complete the AQ questionnaire first, as if their scores were greater than 32 they would have been excluded. This method has been used in previous studies as those who scored over 32 were to be considered for a clinical assessment for diagnosis (Baron-Cohen, 2001). Once they met the inclusion criteria they then proceeded with the verbal and spatial working memory span task and the MASC-MC. They were given the option of having short breaks between each tasks to avoid fatigue or boredom. Once completed participants were given a debrief sheet.

2.5. Method of analysis

The analysis’ used were two multiple regressions. The first to determine whether spatial working memory, verbal working memory or theory of mind can be used to predict autistic trait scores and the second to determine whether verbal or spatial working memory were predictors of theory of mind.
3.0 Results

A multiple regression was conducted in order to investigate whether theory of mind, verbal and spatial working memory were good predictors for autistic traits. Results are shown below in table 1.

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>SE B</th>
<th>β</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ToM</td>
<td>-.667</td>
<td>.111</td>
<td>-.685</td>
<td>-5.996</td>
<td>.000</td>
</tr>
<tr>
<td>Rotation</td>
<td>-.279</td>
<td>.594</td>
<td>-.054</td>
<td>-.470</td>
<td>.641</td>
</tr>
<tr>
<td>(Spatial WM)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading</td>
<td>-1.268</td>
<td>.810</td>
<td>-.165</td>
<td>-1.564</td>
<td>.125</td>
</tr>
<tr>
<td>(Visual WM)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1. The unstandardized and standardised regression coefficients for theory of mind spatial and verbal working memory in autistic traits

In support of the previous prediction, results from the analysis showed that theory of mind was a significant negative predictor of autistic traits and for every 1 unit increase in autistic traits, theory of mind decreased by .685, with a high t-value and low significance values. This shows that theory of mind has a large impact on the criterion variable. The analysis also showed a decrease in the rotation task by .054 and the reading task by .165. From this analysis a significant regression equation emerged: F(3,41) = 23.384, p < .000. The model found that the predictor variables account for 60.4% of the variance (Adjusted R² = .604). However, the reading and rotation span task for verbal and spatial working memory showed little to no significance in predicting autistic traits.

As theory of mind showed to be the only significant predictor of the AQ, a second multiple regression was conducted to see if verbal or spatial working memory were predictors of theory of mind, see table below.
<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>Std. Error</th>
<th>(\beta)</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotation</td>
<td>-.699</td>
<td>.110</td>
<td>-.680</td>
<td>-6.381</td>
<td>.000</td>
</tr>
<tr>
<td>(spatial WM)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading</td>
<td>1.058</td>
<td>.565</td>
<td>.200</td>
<td>1.874</td>
<td>.068</td>
</tr>
<tr>
<td>(verbal WM)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. The unstandardized and standardized regression coefficients for spatial and verbal working memory in theory of mind

Results from the second multiple regression analysis showed that the spatial working memory task has a significant negative effect on theory of mind performance \(F(2, 42) = 36.181, p < .000\). The analysis found that spatial working memory accounts for 61.5% of the variance in theory of mind (Adjusted \(R^2=.615\)). However, verbal working memory has no significant effect on theory of mind performance.

Results from both analysis show that theory of mind predicts AQ, but spatial and verbal working memory do not. However, spatial working memory is a negative predictor of theory of mind whereas verbal memory is not. Therefore, spatial working memory is not directly related to AQ, rather spatial working memory indirectly predicts AQ through the mediating variable – theory of mind.

4.0 Discussion

4.1. Main Discussion

Recent investigations suggest that autism related difficulties in social and executive processing extend beyond individuals diagnosed with ASD. While there is an increasing interest in the link between executive control and mentalising and their respective relationship to autism, little research has been conducted looking at visual and spatial working memory and theory of mind in respect of autistic traits on a subclinical level. In the current study, this gap in literature is addressed by examining links between these constructs and their predictive relationships in typically developing adults. This study replicates and extends previous research that has assessed executive function and autistic traits, as executive function is merely an umbrella term for many cognitive functions (Hill, 2004). It extends findings of 1) a positive association between autism and executive difficulties and 2) spatial and verbal working memory in those with a clinical diagnosis of autism. The main purpose of
the current study was to examine what variables can predict scores on the autistic quotient
(AQ) questionnaire, and to explore whether spatial and verbal working memory are predictors
of theory of mind.

As predicted, data from the first multiple regression revealed that theory of mind was a
negative predictor of autistic traits. Meaning that when a person’s performance is particularly
low on a theory of mind task, then they are predicted to score quite high on the AQ
questionnaire and show elevated levels of autistic traits. By contrast neither spatial nor verbal
working memory had a significant impact on autistic traits directly. The findings of theory of
mind negatively predicts autistic traits converges with other literature, such as Gokcen et al.
(2016). This finding captures the profound theory of mind deficits and subtle mind reading
impairments in the typically developing population (Dziobek et al, 2006; Lahera et al, 2014).
However, the lack of association between verbal and spatial working memory and autistic
traits is surprising and inconsistent with previous research, such as William et al. (2005).

As well as demonstrating that theory of mind is linked to elevated levels of autistic traits,
Gocken et al. (2016) also found a positive association between autistic traits and executive
function difficulties; autism predicts poor performance on the MASC; and autism is negatively
related to MASC. However, one of their tasks used to measure theory of mind they used the
“Reading the Mind in the Eyes” test does not reflect real life situations. Although creating it
Baron-Cohen (2001) reported that as there are only two responses a participant can answer
from, therefore is not an accurate measure as the chance of performance is p=.5 making it
too narrow. It needs a wider range to identify individual differences with greater power. This
task also uses static images which is not an accurate representation to the real world rather
just a ‘quick and easy’ measure (Baron-Cohen, 2001; Baron-Cohen et al, 2015).

As theory of mind was the strongest negative predictor of autistic traits out of the three
constructs and it has previously been found that spatial and verbal working memory has some
underlying association with autism (William et al. 2005), a second regression was conducted
to determine whether working memory had any predictive power over theory of mind.
The main findings from this second regression revealed that spatial working memory was a significant negative predictor of theory of mind and verbal working memory had no significant impact. Therefore, showing that spatial working memory is indirectly related to autistic traits through theory of mind.

However findings of verbal working memory having no predictive effect appears to be inconsistent with other research. It has been reported by Bonnetto, Pennington and Rogers (1996) that verbal working memory was impaired in those who displayed elevated autistic traits. Yet remained consistent with other findings by Williams et al. (2005). This inconsistency of findings should be related to type of task and task difficulty. This relates to findings of one of the earlier studies measuring verbal and spatial working memory in those with autism, carried out by Williams et al (2005), who found a dissociation between verbal and spatial working memory within individuals with autism. They found that those with autism have intact verbal working memory and impaired spatial working memory, which remains consistent with other findings such as Ozonoff and Strayer (2001) who reported individuals with autism demonstrating intact verbal working memory and impaired spatial working memory.

It has been found that those with autism demonstrate an impairment in the capacity to remember locations of previously searched boxes over trials compared to typically developing individuals. They also showed failure to consistently develop sequential search strategies to aid performance (Steele et al. 2006). The present study extended previous findings of spatial working memory deficits in those clinically diagnosed with autism by demonstrating that these deficits extend indirectly to individuals who possess elevated autistic traits through theory of mind. Therefore, showing that this difficulty found in those with a clinical diagnosis is a shared trait to those who display elevated trait levels of autism.

However, unless the demands of working memory and theory of mind tasks remain at a consistent level of task difficulty across numerous studies, studies will always fluctuate in findings. From previous findings, it has become abundantly clear that individual differences are important to consider in complex social situations. In certain situations something that is controllable for one person may not be for another. Barret, Tugade and Engle (2004) found
that individual differences within working memory reflects the ability to control attention associated with the central executive aspect of working memory. They believe that individual differences are the source of goal directed behaviour and merely serves to activate, maintain and surprises memory representations. Individual differences in working memory capacity is likely to influence that capability to engage in controlled processing which is believed to determine our ability to control our thoughts, feelings and behaviours in everyday life (Barret et al., 2004). Therefore, individual differences in working memory capacity could influence results negatively as different people maintain a different memory threshold, whether they possess autistic traits or not and therefore strained to reveal deficits (Steele et al, 2007; Morris, Rowe, Fox, Feigenbaum, Miotto et al. 1999).

4.2. Limitations
Predictions for this study were that those who display elevated levels of autistic traits would have a poor performance on the theory of mind task as well as the spatial and verbal working memory task. However, a limitation to this study was the sample size, a replication of this study should require more participants for a higher level of significance and power (Neace, Michaud, Bolling, Deer & Zecvis, 2008). Having a smaller sample level create lower levels of strength. As it has been recently discovered that there is a significant relationship between theory of mind and spatial working memory. Gallini (2014) reported a marginal significance, indicating the presences of a relationship between the two constructs, future research should look to examine in greater depth the link between theory of mind and spatial working memory as it may enable a different way to identify theory of mind difficulties and create new interventions and treatments. It will also help us to understand the link between these two constructs and aim to provide a skill that must be understood across the life span. There was also no control for sex differences within the sample. Therefore, future research could control for this as there have been reports from recent investigations of gender specific cognitive impairments within ASD. It has shown that high functioning males evidence greater deficits within sub-domains of executive control compared to females (Lehnhardt, Falter, Gawronski Pfeiffer, Tepest et al., 2016). Future research should aim to have a more males creating an equal sex split sample, to potentially reveal a stronger association between autistic traits and theory of mind deficits (Bolte, Westerwald, Holtmann, Freitag & Poustka 2011, Gokcen et al, 2016).
4.3. Conclusion

As a result of these findings, several conclusions can be made. It was found that spatial working memory has predictive power over an individual’s theory of mind performance. As well as theory of mind has high predictive power on autistic traits levels. Findings of a link between spatial working memory and theory of mind can provide a number of considerations. This link provides motive for the ability to consider theory of mind in a manner not previously tested in the research (Gallini, 2014). Theory of Mind currently has few methods of assessment outside of research (McKinnon, Cusi & MacQueen, 2010). Given the link between TOM and Visual-Spatial skills, practitioners can consider this construct as a target for intervention and treatment when working with any individual (Gil-Sanz, Fernandez-Modamio, Bengochea-Seco, Arrieta-Rodriguez & Perez-Fuentes, 2014).
5.0 References


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Robinson, E. B., Koenen, K. C., McCormick, M. C., Munir, K., Hallett, V., Happé, F., ... & Ronald, A. (2011). Evidence that autistic traits show the same etiology in the general population and at the quantitative extremes (5%, 2.5%, and 1%). *Archives of general psychiatry, 68*(11), 1113-1121.


6.0 Appendix

Appendix A:

CARDIFF METROPOLITAN UNIVERSITY
APPLICATION FOR ETHICS APPROVAL

Title of Project: The relationship between visual and spatial working memory, theory of mind and autism traits in the normal population

Participant information sheet

The study:
The current study is to explore the relationships between verbal and spatial working memory, theory of mind and autism traits in non-clinical populations.

What would happen if you agree to participate?
If you agree, you will take part in four tasks. You will first complete the Autism-Spectrum Quotient (AQ) Questionnaire. Your score on the AQ will then determine whether you continue in the study. If you do continue you will be required to view short video clips of people interacting, followed by some multiple choice questions. Two further tasks that assess working memory.

Exclusion criteria
If you are known to have a clinically diagnosed of an autism-spectrum disorder than please inform the researcher and you will be excluded from the study as it is looking at autism traits in sub-clinical populations. You will be excluded if you are under 18.

Potential Risk
Potential risks from this study may include fatigue and boredom, therefore breaks will be provided between tasks.

The Autism-Spectrum Quotient (AQ) is not a diagnostic measure of autism spectrum disorders. Should you have any concerns about your wellbeing please contact student services (029204116170, studentservices@cardiffmet.ac.uk) and or your General Practitioner.

Potential benefits
Potential benefits include insight into experimental testing and gaining participation credits

Withdrawal, anonymity and confidentiality:
Anonymity will remain throughout this study as no personal information will be asked of you throughout these tasks. The data produced will remain on a password protected computer and only myself, supervisor and developers of the MASC will have access to the data. As there is no way of determining your results from anyone else the cut-off point of withdrawal will be at the time of your participation during data collection.

If you have any questions about the study, please contact: dskillcorn@cardiffmet.ac.uk
PARTICIPANT CONSENT FORM

Reference Number:

Participant name or Study ID Number:

Title of Project: Exploring Theory of Mind and Visuospatial Working Memory in Typically Developing Adults with High Levels of Autistic Traits

Name of Researcher:

__________________________________________________________________________

Participant to complete this section: Please initial each box.

1. I confirm that I have read and understand the information sheet for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. □

2. I understand that my participation is voluntary and that I am free to withdraw at any time before leaving the experiment, without giving any reason. □

3. I agree to take part in the above study. □

_________________________________________  ____________________________
Signature of Participant                     Date

_________________________________________  ____________________________
Name of person taking consent                Date

__________________________________________
Signature of person taking consent

Application for ethics approval 1 August 2022
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Signed: ________________________________

Date: 20/04/2018 ________________________________