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The relationship between sustained and divided attentional abilities and Autistic Spectrum Disorder traits

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Abstract

Whilst social and communication impairments represent the defining features of Autistic Spectrum Disorders (ASDs), the proposed comorbidity between ASD and Attention Deficit Hyperactivity Disorder (ADHD; Leyfer, 2006) suggests attentional deficits may also be an underlying feature of ASD. The DSM-IV-TR precludes a dual-diagnosis of ASD with ADHD and symptoms of attention deficits are not included in the DSM-IV-TR or the ICD-10 diagnosis for ASD. There is currently inconsistent literature surrounding what types of attentional difficulties exist in ASD, if any. As undiagnosed ASDs are suspected to be a leading cause of expulsion from schools (Skuse *et al,* 2010), the present study aims to explore sustained and divided attentional abilities as they are known to have a relationship with academic performance (Gordon *et al,* 1994), in children across a continuum of autistic spectrum disorder traits, using a novel objective measure of attention. 80 children (M=40, F=40, aged 7-11) were recruited from a primary school in the 'Born in Bradford' cohort. Sustained attention was measured on tracking and cue-detection tasks on a tablet laptop, and divided attention was measured by performing both tasks together under dual-task conditions. Information was gathered for each child from their main teacher using the Strengths and Difficulties Questionnaire (Goodman *et al*, 2001); three subscales of which have previously been found to represent ASD traits (Iizuka *et al*, 2010; Russell *et al,* 2012). Results revealed that sustained and divided attention capacity does appear to be poorer in children who display greater ASD traits. Linear regressions suggest that sustained and divided attention explains more variance in certain ASD traits than others in particular pro-social behaviour, reasons for this are discussed. Further analysis with regression investigates the relationship between constituent components of the attention measures and each ASD trait measured.

1. Introduction

1.1 Autistic Spectrum Disorders

Autistic Spectrum Disorder (ASD) umbrellas a range of neurodevelopmental conditions including Autism, Asperger's Syndrome and Pervasive Developmental Disorder-Not Otherwise Specified (Johnson$_a$ *et al*, 2007). These are typically characterised by qualitative impairments in social interaction and communication, alongside restricted, repetitive and stereotyped patterns of behaviour, interests and activities (DSM-IV TR; American Psychiatric Association, 2000). Most epidemiology reviews estimate the prevalence of ASDs at 6 per 1000 individuals (Newschaffer *et al,* 2007), which is consistent across cultures and ethnicities (Mash *et al,* 2003); although affecting more males than females with a ratio of 4.2:1 respectively (Fombonne, 2009).

The prevalence of reported ASDs has increased in recent years (Rutter, 2005), demonstrating the need for improved understanding and treatments. This increase however, may be due to heightened surveillance and broadening of the ASD definition (Taylor, 2006). Despite this, many children with ASD are left undiagnosed, with a ratio for known to unknown cases of 3:2 (Baron-Cohen *et al*, 2009). This is a problem as the Institute of Child health (2010) claims that undiagnosed ASDs are a leading causes of expulsion from schools. In 2010 they studied 26 children from 16 different schools whom were expelled due to disruptive behaviour, with no underlying ASD diagnosis. Using standardized tests they diagnosed 9 as having ASD which may have accounted for their behaviour (Skuse *et al,* 2010).

1.2 Comorbidity of Autistic Spectrum Disorder and Attention Deficit Hyperactivity Disorder

Children with ASD frequently show behaviours other than those described in the DSM-IV-TR criteria (Lainhart, 1999). Around 55% of children with ASD exhibit Attention Deficit Hyperactivity Disorder (ADHD) symptoms (Leyfer, 2006), which comprise of inattention, hyperactivity and impulsiveness (DSM-IV TR, 2000); 65% of these display the inattentive ADHD subtype (Leyfer, 2006) which constitutes attentional deficits, particularly the inability to stay on task. This suggests that attention deficits may also be evident in children with

ASD, alongside the defining feature of social impairments. Very early descriptions of autism acknowledged attention deficits in symptomology (Kanner *et al*, 1943); likewise Sturm *et al* (2004) observed attentional deficits in 95% of their ASD sample. More recent research by Goldstein *et al* (2004) studied 101 individuals with ASD, of which 75% displayed ADHD symptoms suggesting at least a subgroup of ASD individuals that present with ADHD symptoms. Despite these findings, the DSM-IV-TR does not allow an ADHD diagnosis if symptoms are associated with ASD; further no symptomology of attentional deficits currently exists in the DSM-IV-TR (appendix A) or the ICD-10 (appendix B) criteria for ASD.

Attention is an extensively studied topic in psychology and is a well-known concept that can be measured. There is no single definition of attention but essentially it involves directed concentration on a task (Eriksen, 1986). Psychologist William James (1980) further stated that “attention implies withdrawal from some things in order to deal effectively with others." Although there are many subscales of attention; due to the growing amount of literature suggesting attentional deficits in ASD may contribute to expulsion (Skuse, 2010) or affect performance in school (Dickerson *et al*, 2003), this thesis will focus on sustained and divided attention which are known to have a relationship with academic performance based on previous research.

1.3 Sustained Attention in Autistic Spectrum Disorders

Sustained attention (SA) is a self-directed process involving sustained, conscious processing of stimuli, where repetitive qualities would otherwise lead to habituation and distraction (Robertson *et al,* 1997). A SA deficit would lead to a ‘significant decrement in task performance with task duration’ (Meere *et al*, 2006). SA is shown to predict academic achievement: Gordon *et al* (1994) found SA deficits led to a higher probability of grade retention; furthermore Chee *et al* (1991) discovered a significant relationship between reading scores and SA as measured on the Continuous Performance Task (Klee & Garfinkel, 1983); it has also been suggested that SA predicts classroom behaviour (Lehman *et al*, 2006).

There is limited research on ASD and sustained attention, which may be partly because SA is a difficult phenomenon to sensitively measure. There are inconsistencies in the available literature in this area with few findings suggesting impaired SA in ASD; however Corbett *et*

al (2006) used the Integrated Visual and Auditory (IVA) Continuous Performance Test (CPT; (Sandford & Turner, 2000), to examine SA in 15 children with ASD, 15 with ADHD and 15 typically developing controls matched for age and gender. Both ASD and ADHD children showed significant undistinguishable deficits in performance compared to controls, suggesting that individuals with ASD may also display sustained attention deficits. More recently Christakou *et al* (2013) conducted a neuroimaging study using FMRI to compare brain activity in boys with ASD, ADHD and age matched controls whilst performing a SA task. Results confirmed previous findings by Corbett (2006) and suggest ASD and ADHD boys share the same neurofunctional abnormalities during tasks of sustained attention.

Most studies examining ASD have however, reported no deficits of sustained attention (Buchsbaum *et al,* 1992; Casey *et al,* 1993; Noterdaeme *et al*, 2001). For example Minshew *et al* (1999) tested autistic children on attention tasks and observed no difference in SA performance compared to typically developing children. Similarly Courchesne *et al* (1989) found children with ASD did not display difficulties maintaining attention on a single source. Furthermore Garretson (1990) examined performance of autistic children on a Continuous Performance Task of sustained attention compared to age matched controls. Their results demonstrated impaired SA in autistic children, but only during the social motivation condition (when praised after every fifth target was hit), suggesting the findings are more likely attributable to social motivators being less effective in ASD, than to a primary SA deficit. Johnson$_b$ *et al* (2007) claimed that variability in response time (RT) is an important measure in SA tasks which was not measured by Buchsbaum or Garretson; thus Johnson$_b$ (2007) measured RT but still observed intact sustained attention in children with ASD compared to controls.

More recently it's been suggested that individuals with ASD may have superior abilities to sustain attention, particularly on topics or objects that interest them (Plaisted *et al*, 2009). This may explain repetitive behaviours such as lining up toy cars or counting matchsticks. This has been demonstrated by individuals with ASD displaying superior performance on embedded figures tasks which require focused attention for a period of time (Jolliffe *et al*, 1997). A narrow focus of attention has been acknowledged as a deficit of attention in ASD

(Lovaas *et al,* 1979), however research on the extent to which this can be applied to sustaining attention over time is limited. Thus, the nature of sustained attention deficits in autism remains to be fully determined (Johnson$_b$, 2007).

1.4 Divided Attention in Autistic Spectrum Disorders

Dividing attention (DA) involves concentrating on two things at once, however Herings' (1977) law of equal innervation states it's impossible to look in two places at once as both eyes are controlled as a single organ; thus with regards to visual DA one must essentially move their eyes in order to meet dual task requirements. A DA deficit 'implies a reduced ability to process high levels of cognitive load simultaneously' (Althaus *et al*, 1996). Like SA, DA is also associated with academic achievement: Mizuno *et al* (2012) observed relationships between poor divided attention, fatigue, and low academic motivation in junior high school children, which affected educational performance. Furthermore Warshaw (1979) demonstrated that improved DA lead to improved academic performance. This may be due to the importance of being able to divide attention in a classroom setting between the teacher and the work; thus DA is an essential skill required in order to learn new things and rehearse new skills in everyday scenarios (Huang, 2001), and difficulties here may affect learning.

Most research on ASD and DA has focused on dividing attention across different modalities (e.g. visual and auditory). This may be because being able to DA between simultaneously perceived perceptual signals is argued to be crucial for social behaviour (Magnee *et al,* 2011), which is seen as a defining deficit in ASD. A number of studies show support for a cross-modal divided attention deficit in ASD. Allen *et al* (2001) found an impaired ability in autistic participants to divide attention between visual and auditory sources of information. Likewise Courchesne *et al* (1994) hypothesized a deficit in ability to disengage attention in ASD; which was demonstrated in the increased reaction time when required to shift attention between modalities in autistic participants compared to controls. Similar findings were demonstrated by Magnee (2011), Ciesielski *et al* (1995) and Casey *et al* (1993), although Bogte *et al* (2009) argued that the sample size was too small in the latter two studies (n=8, n=10). Furthermore Casey (1993) did not screen for psychotropic medication

known to have an effect on reaction time (Scheepers *et al*, 2001), which may have confounded results.

There is inconsistent evidence surrounding whether DA is governed across or within modalities (i.e. both visual tasks), although Navon and Gopher (1979) suggest it's harder to divide attentional resources when tasks are from the same modality due to interference; which is consistently agreed upon (Alais *et al,* 2006); and what is essentially required in a classroom setting when paying attention to the teacher and the work. Some studies have shown a deficit of DA in ASD children at a modality specific level (Pierce *et al*, 1997; Koldewyn *et al,* 2012; Landry *et al,* 2004, Swaab-Barneverd, 1998). For example Althaus (1996) tested 19 children aged 8 to 12 with a diagnosis of Pervasive Developmental Disorder (PDD) using the Shiffrin and Schneider (1977) paradigm, which involved only a visual stimulus modality to be triggered. The results demonstrated a significant impairment in reaction time when PDD children were required to divide attention, compared to intelligence and age-matched controls. Similarly, Wainwright-Sharp and Bryson (1993) found deficits in autistic individuals ability to shift attention within the visual modality throughout Posner's (1978) visual orienting task, demonstrated by their failure to display the normal reaction time advantage which is expected for correctly cued targets. Moreover children with ASD have self-reported difficulties on tasks that require DA, and often adapt different strategies compared to controls on these tasks (O'Neill *et al,* 1997).

Despite the wealth of literature that proposes a DA deficit in ASD, a handful of studies oppose these findings and propose typical or improved DA in ASDs. Bogte *et al* (2009) observed a DA deficit in a visual search paradigm, but only in ASD participants that were taking psychotropic medication; it has already been established that this medicine affects reaction time. Although this study suggests no DA deficit in ASD participants not taking medication, discrepancies with past research may be due to an adult sample, as it not fully understood how DA develops with age (Hill, 2004), although it has been suggested that the extent of secondary task interference during childhood declines with age (Guttentag, 1989). Furthermore Rutherford *et al* (2007) found subjects with autism performed better on a visual search paradigm under DA conditions than controls, suggesting a DA advantage in ASD. In this study participants were not required to expand attentional focus, or integrate

information across different parts of the visual field, thus the differences in results may be accounted for by different stimuli.

It's difficult to understand attention deficits in ASD independent of their association with social difficulties. It's long established that children with ASD have problems attaining to social stimuli, for example poor eye contact with parents (Kope *et al*, 2001). Recent research by Shic *et al* (2011) suggests young children with ASD pay more attention to non-social objects and less attention to social aspects of the environment than typically developing children, which may affect learning in school if the child struggles to pay attention to the teacher (Dawson *et al,* 2012), as the teacher is a social aspect of the environment.

1.5 The Present Study

The present study was a constituent part of 'Born in Bradford' (BIB) research. The born in Bradford study is following 13,500 children in Bradford from birth to adulthood to track their health, and identify those at increased risk of health problems. The rationale behind BIB study stems from the fact that Bradford is one of the most deprived areas in the UK, with infant mortality being consistently above national averages, thus the need for new health and social interventions to assist children more effectively with disorders such as ASD is essential. A large focus is also being placed on improving academic achievement as the children begin education. The present study explores the relationship between sustained and divided attentional abilities across a continuum of ASD traits in a stratified random sample of 80 children from a primary school in Bradford.

Past studies have focused on measuring attention in individuals diagnosed with ASD compared to typically developing individuals. There are disadvantages of using a 'between-group' approach in studies of this nature, as it's well established that ASDs are not definite single disorders, but rather they exist along a continuum with different levels of severity. Disadvantages of between-group studies include: an overrepresentation of severe ASD as participants must have had significant symptoms to acquire a clinical diagnosis; small sample size as it's hard to recruit a large group of diagnosed autistic children (Corbett *et al*, 2006); risk of a false diagnosis of ASD from clinician which may lead to false conclusions; difficulty generalizing results to the general population; and an overrepresentation of males as it's well established that ASD affects significantly more males than females (Fombonne,

2009) . Thus a 'population' based study, involving a normally developing population of children was deemed more appropriate for this study, as such a sample is more likely to contain a normal distribution of children displaying different levels of ASD traits on a continuum that is representative of the general population.

1.5.1 Sustained and Divided Attention Measures

One of the most common 'gold standard' tools used to measure SA in ASD children is the Continuous Performance Task (CPT) which requires participants to concentrate on repetitive tasks in order to correctly respond to targets, or inhibit responses to non-target stimuli (Shalev *et al,* 2011). There are a range of CPT's including Connor's CPT, IVA, GDS and T.O.V.A., which measure correct responses, reaction time, and commission and omission errors (Connor's, 2000; Impara *et al,* 1998; Gordon *et al,* 1988). The CPT score is compared against a norm score matched for age and gender (Connor's, 2000).

To date there is no well-established tool to measure DA in children. Current methods used to assess divided attention usually involve a variation of the CPT with an additional task included e.g. counting or listening to auditory stimuli (Salthouse, 2003). Most have involved dividing attention across different modalities, despite previous research suggesting it's harder to divide attentional resources when tasks are from the same modality (Navon *et al,* 1979).

However the ability of CPT's too accurately measure attention has been questioned; Sanders *et al* (2007) argues CPTs are more a measure of performance deterioration than accuracy levels. Likewise correlations between omission errors and poor attention are low suggesting omission errors may not always be an accurate measure of low attention when used alone (Barkley, 1990). In addition low correlations have also been reported between parent and teacher ratings of child's behaviour and CPT's (Lovejoy *et al,* 1990), challenging its validity. Attention is a highly fluid process that fluctuates; despite this CPT's do not currently measure intra-individual variability (stability of attention throughout duration of task; Hill *et al,* 2012).

The present study will attempt to overcome these issues by assessing sustained and divided attentional abilities objectively on a portable tablet laptop developed by Culmer *et al* in

2009, which can be used in a classroom setting whilst still ensuring accuracy and power of laboratory measures. The visuo-motor attention measure that runs off the laptop was created by Hill *et al* (2012) to obtain objective measurements of SA and DA. The measure has advantages over CPT's as it measures intra-individual variability which has been shown to vary more in children with attention deficits compared to controls on serial reaction time tasks (Helps *et al*, 2011); it also requires attention to be divided across a specific visual modality which is essentially what is required in a classroom setting when children divide attention between the teacher and the work in front of them. In addition the attention measure has high ecological validity as the task requires movements similar to those made when handwriting. In summary the task provides a measure of SA and DA associated with previous CPT tasks, in addition to visuo-motor measures of attentiveness (Hill *et al,* 2012).

1.5.2 Strengths and Difficulties Questionnaire

The strengths and difficulties questionnaire (SDQ) is used to screen behaviour in children aged 3-16 against a norm reference group (see appendix C). It was developed in the 1990s by psychiatrist Robert Goodman (Goodman, 1997) and consists of 25 items measuring psychological attributes: 4 scales measuring difficulties (emotional symptoms, conduct problems, hyperactivity, and peer problems), and 1 scale measuring strengths (pro-social). The questionnaire can be downloaded for free and filled out by parents, teachers or children and takes on average 5 minutes to complete. SDQ scores have good concurrent validity (correlate with other psychopathology measures), internal consistency, and test-re-test reliability (Russell *et al,* 2012).

A study by Iizuka *et al* (2010) previously examined SDQ subscales in children with ASD. They found that compared to controls, ASD children scored significantly higher on emotional symptoms and peer-problems scales when rated by parents, and higher on peer-problems and lower on pro-social behaviour when rated by teachers. Posserud *et al* (2008) found most of the variance in the Autism Spectrum Screening Questionnaire was explained by a single factor of social interaction, which strongly correlated with the peer problems SDQ scale. Russell *et al* (2012) further demonstrated that the pro-social scale strongly correlated with an autism diagnosis in the Avon Longitudinal study of Parents and Children (ALSPAC) cohort. In addition these three subscales were previously analyzed and combined as a

measure of ASD traits (O'Neill, 2012). Iizuka *et al* (2010) reiterated that the SDQ is a screening tool to help indicate further services or treatment that may be required, and is not a diagnostic tool itself.

Based on these findings, the current study will explore relationships between the emotional symptoms (marked 'e' in appendix C), peer-problems (marked 'pp' in appendix C) and pro-social behaviour (marked 'ps' in appendix C) SDQ scales and the attention measures. SDQ's will be completed by teachers as they can observe how children interact with a number of other pupils and adults on a daily basis. Each item is marked either 'not true' = 0, 'somewhat true' = 1 or 'certainly true' = 2 for all items except those where scoring is reversed (see items with a * in Appendix C). An overall score for each scale ranging from 0-10 is devised by summing up each item in the scale.

1.6 Aims and Research Question

Aim

The aim of the study is to explore sustained and divided attentional abilities of children along a continuum of autistic spectrum disorder traits.

Research Question

Does the presence of autistic traits (as measured by the SDQ) influence performance on tasks that require sustained attention or divided attention. Previous literature suggests that performance on these tasks will be differentially affected.

2. Methods

2.1 Participants

All participants were recruited from Allerton Primary School in Bradford that is part of the 'Born in Bradford Cohort', through an opportunistic sample, aged between 7 and 11 years old. Around 250 participants were tested, however a random sample of 80 of these (20 from each year) stratified for sex, were included for analysis due to time limits (N=80, male =40, female =40, right handed =72, left handed=8).

Teachers at the school informed researchers that children under age 7 may struggle to perform the attention task, thus a pilot study was conducted on a group of children from year 2 (age=6). As suspected they struggled to comply with task demands (e.g. switching stylus in hands, lifting pen off screen). Due to this the current study only tested children from year 3 and above.

The sample represents children in diverse mainstream education, thus some neurodevelopmental disorders are presumed to be under diagnosed due to the low socio-economic status of the area and high prevalence of genetic disorders.

2.2 Ethics

Ethical approval was obtained from the University of Leeds Institute Of Psychological Sciences Research Ethics Committee. The study complied with the ethical standards set out in the 1964 Declaration of Helsinki.

A parental 'opt out' form was distributed to all parents prior to their child's inclusion in the study. Children gave verbal consent before performing the task, and were informed that they could leave at any time if they didn't want to continue. All experimenters obtained valid CRB checks to ensure safety of the children; and confidentiality of participants was protected by ensuring all data was stored in secure computer files.

2.3 Design

The cross-sectional study was a repeated measures design as all children took part in all attention tasks.

2.4 Apparatus/Materials

2.4.1 Attention Measure

All visuo-motor attention tasks were carried out on a portable Toshiba Model Tecra M7 tablet computer (screen: 303x190mm, 1600x1200 pixels, 16 bit colour, 60 Hz refresh rate). The screen rotated 180 degrees and folded down to resemble a normal horizontal writing surface that participants could engage with using the pen shaped stylus (14cm x0.9cm diameter). Integrated sensors measured the planar position of the stylus held in their preferred writing hand at a rate of 120 Hz (Culmer *et al*, 2009).

The experimental tasks were run on a specialised software programme called KineLab (created using the LabVIEW programming environment, version 8.21, National Instruments™). The tablet provides a highly portable device, allowing a measure of human movement in configurable visuo-spatial tasks. Culmer *et al* (2009) claimed 'kinelab consists of a framework that: (i) enables rapid development of standardised kinematic assessment trials; (ii) conducts interactive assessment trials and records kinematic data; (iii) automates data analysis to generate standardised performance metrics'. For a full overview of the KineLab software see Culmer, Levesley, Mon-Williams & Williams (2009).

2.4.2 Strengths and Difficulties questionnaire

The SDQ (Goodman, 2005) was accessed and downloaded on 01/12/2012 from: http://www.sdqinfo.org/py/sdqinfo/b3.py?language=Englishqz(UK)

The pro-social behaviour subscale was reversed so a higher score now meant less pro-social behaviour, indicating higher ASD traits (Russell *et al*, 2012). This enabled the subscales to be grouped together by ensuring all scores were in the same direction as higher scores on peer problems and emotional symptoms subscales also indicate higher ASD traits (Iizuka *et al*, 2010).

2.5 Procedure

Participants entered the testing room and were briefed in groups of 7. Each participant then sat at a table with an experimenter who ensured they could comfortably access the laptop. After entering participant's details into the laptop, the screen was rotated, folded down, and placed at a comfortable distance in front of each participant on the table so they could

easily complete the tasks. Handedness was established by placing the stylus in front of the participant and asking them to hold it with the hand they usually write with. All participants previously completed a C-KAT task on the tablet (testing motor abilities – Culmer *et al*, 2009) as part of a co-existing study with a delay of between 2 hours to 10 days before completing the attention task.

Participants were informed there would be 3 attention games: tracking, shape-spotting and a combined task, lasting 3 minutes each. All instructions were displayed in clear, comprehendible language on the screen (including screen shots of each game), however due to the young age of participants the experimenters also orally explained the instructions. A practice trial lasting 10-15 seconds preceded each game allowing participants to become familiar with the stylus and tasks. Throughout all the trials participants were encouraged to keep the pen touching the screen at all times to ensure accurate recording of data.

The first two games were baseline measures indicative of sustained attention performance. These baseline measures allowed performance on the tasks to be compared between single and dual task conditions (when both games were combined), to provide a measure of participants' ability to divide attention. The basic layout was similar for all games: four dots on the screen, one in each corner connected by arrows stating the direction in which participants should move the stylus. There was also a small cue box at the top of the screen in the centre. The following information describes what was different about each task:

Tracking task – sustained attention

Participants were instructed to place the stylus on the bottom left-hand red dot (figure a) and after a two second delay begin tracking the dot as it moved around the screen in the bottom left-hand quadrant (figure b). Participants were instructed to keep the tip of the stylus as close as possible to the centre of the dot. This task provided a baseline measure of sustained attention performance.

Performance was recorded in the form of a time-series of Tracking Errors (TEs), which are the straight line distances between the dots centre and the stylus, recorded 120 times per second. TEs were square-root transformed and summarised by the mean to give root mean

square (RMS) and standard deviation (SD) of errors. Larger scores on these outcomes imply lower accuracy and greater fluctuation in performance (Culmer *et al,* 2009).

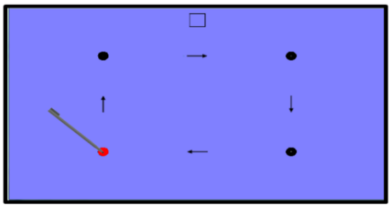

Figure a. Tracking task

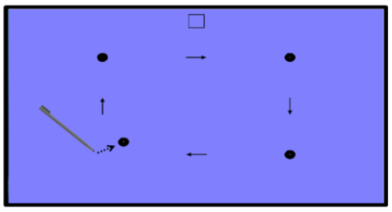

Figure b. Dot turns black and begins to move

Shape Spotting Task – sustained attention

Participants held the stylus on the bottom left-hand red circle which after a two second delay prompted shapes to flash in the cue box for 0.5 seconds each (figure c). When participant's detected a 'cross' followed by a 'circle' in the cue box, they were required to move the stylus to the next stationary dot as stated by the arrows (figure d); they continued to do this for the remainder of the trials. Participants were instructed not to guess and only to move to a new circle when they were certain. This task was also a baseline measure of sustained attention.

Performance was recorded in terms of correct reactions (CRs) in which the correct target was moved to. A second analysis was mean reaction time (MRT) in seconds, calculated for valid reactions only. This indicated processing speed of participants in response to cues.

False reactions (FRs) were defined as the number of switches to another target made despite no valid cue being present.

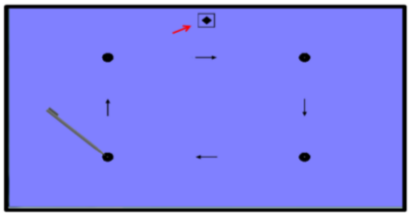

Figure c. Shape spotting task

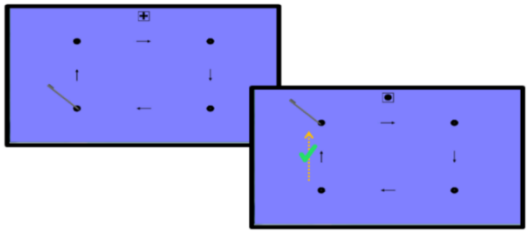

Figure d. Cross followed by a circle prompted move to next dot

Tracking and Shape Spotting combined task – measure of divided attention

This task involved a combination of the tracking and shape spotting tasks, to measure the degree to which performance changed under dual task compared to single task conditions; providing a measure of divided attention. Participants began with the stylus on the red dot in the bottom left-hand corner of the screen, and after a 2 second delay all four dots began to move in their own quadrants (figure e). Participants were instructed to track the current dot by keeping the stylus at close to the centre of the dot as possible, whilst at the same time paying attention to the shapes in the cue box (figure f). When they detected a 'cross' followed by a 'circle' in the box, they were instructed to move the stylus clockwise to the next moving dot and begin tracking the new dot (figure g).

Performance measures for the previous two tasks were all measured in this task.

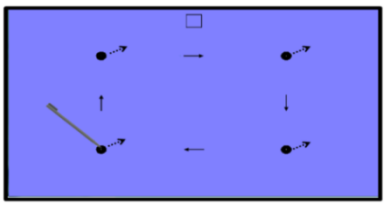

Figure e. All four dots moving

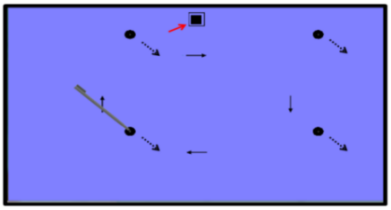

Figure f. Tracking current dot and shape spotting

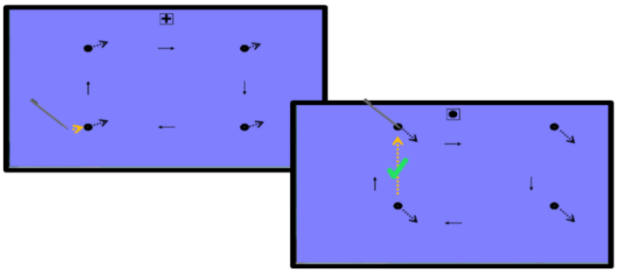

Figure g. Moving stylus to track next dot after detecting required shape sequence

2.6 Analysis

2.6.1 Measures

Overall SDQ score was obtained by summing up the reversed pro-social behaviour, emotional difficulties, peer problems, hyperactivity and conduct problem scores. Higher scores on all indicate more behaviour difficulties.

A composite ASD trait score was derived for each child by summing up the reversed pro-social behaviour, emotional difficulties and peer problem scores. A higher score indicates more ASD traits.

Complete SDQ and attention battery data sets were collected for all participants. Composite scores for sustained, divided and overall attentional abilities were created from each participant's performance on the attention task.

Z scores were created for each variable by taking a variable e.g. RMS, and from each RMS score subtracting the mean value of all RMS scores before dividing by the standard deviation of RMS. This enabled all scores to be converted into the same standardised unit so they could be grouped and compared against each other.

Composite Sustained Attention score

For each participant Z scores were created for the root mean square (RMS) and standard deviation (SD) of error for the tracking task; which were averaged to give an overall SA tracking score. Z scores were also created for the number of correct reactions (No.CR's), number of false reactions (No.FR's), and mean reaction time (MRT) for the cue detection task; which was averaged to give an overall SA cue-detection score for each participant. A composite SA score was created by averaging all 5 subscales (i.e. RMS, SD, No.CR's, No.FR's and MRT)

For the purpose of analysis, the No.CR's subscale was reversed for SA measures so that a lower score indicated better performance in line with the No.FR's, MRT, RMS and SD subscales. Original scores were used for No.CR's$_{DTD}$ as this is a measure of the difference between scores from single to dual-tasking, and this difference remains the same even after reversing No.CR's for SA measures.

Composite Divided Attention score

Scores from each of the five SA subscales were subtracted from scores on each corresponding subscale during the combined task to provide a score of dual task difference (DTD) for each subscale (e.g. MRT on combined task – MRT on SA cue-detection). This indicated participants change in performance on the combined task compared to the single tasks, after adjusting for participant's basic tracking and cue-detection ability. This lead to

five new subscales: $RMS_{DTD,}$ $SD_{DTD,}$ $No.CR's_{DTD,}$ $No.FR's_{DTD,}$ MRT_{DTD}. These indicated participant's ability to divide attention; higher scores on all measures indicated a greater decrement in performance between the two tasks.

Z scores were then created for each of these five DTD subscales. Z scores for RMS_{DTD} and SD_{DTD} were averaged to give an overall tracking DA score. Z scores for $No.CR's_{DTD}$, $No.FR's_{DTD}$ and MRT_{DTD} were averaged to give an overall cue-detection DA score. A composite DA score was created by averaging all 5 DTD subscales.

Overall attention score

SA tracking, SA cue-detection and overall DA Z scores were averaged to provide an overall measure of performance on the attention tasks for each child.

2.6.2 Statistics

Preliminary correlations were conducted for the overall SDQ score and ASD trait measures (dependent variable) with the attention measures (Independent variables). Linear regressions were then conducted to examine these relationships in more detail; these included semi-partial correlations controlling for age. All data was statistically analysed using IBM SPSS 20. Relationships and variance explained were considered significant at $p<.05$.

3. Results

3.1 Correlations

Preliminary analysis to investigate relationships between the attention measures and total SDQ score were conducted using Pearson's correlation coefficient (r).

Table 1. Correlations for composite attention measures and total SDQ score.

Measure	Composite overall attention score	Composite DA score	Composite SA score
Total SDQ score	r(80)=.478**	r(80)=.285*	r(80)=.368**

*=p≤0.05, (2-tailed
**= P≤0.01, (2-tailed)

All composite attention measures correlated significantly with total SDQ scores, showing the higher a participant's overall SDQ score is (more difficulties), the higher their attention scores are (indicates lower performance).

Furthermore, Pearson's correlation coefficient (r) was used to determine relationships between attention measures and ASD traits as measured by the SDQ.

Table 2. Correlations for composite attention measures and ASD trait measures.

Measure	Composite overall attention score	Composite DA score	Composite SA score
Composite ASD traits	r(80)= .372**	r(80)= .128	r(80)= .318**
Reversed pro-social behaviour	r(80)= .395**	r(80)= .234*	r(80)= .305**
Peer problems	r(80)= .306**	r(80)= .025	r(80)= .291**
Emotional symptoms	r(80)= .395**	r(80)= -.025	r(80)= .054

*=p≤0.05, (2-tailed
**= P≤0.01, (2-tailed)

Significant correlations were found for composite ASD trait scores with overall attention and SA scores, demonstrating that as participants display more ASD traits they perform less

accurately on SA tasks indicated by higher scores. Significant correlations were also found for overall attention scores and ASD trait subscales. The reversed pro-social scale was the only ASD trait subscale that correlated significantly with all attention measures. This shows that as participants display less pro-social behaviour (higher reversed pro-social score), they perform less accurate on all attention measures.

3.2 Linear regressions

3.2.1 Divided Attention, Sustained Attention and Composite ASD traits

A strong positive relationship was found between composite attention measures and total SDQ scores, however further analysis was required to deeper explore relationships between attention tasks and composite ASD trait scores.

Separate linear regressions indicated that overall attention, and composite SA scores explained a significant amount of variance in the composite ASD traits, with overall attention measure explaining 14% (r^2= .14, F (1, 78) = 12.5, p<0.001), and SA measure explaining 10% of the variance (r^2= .10, F (1, 78) = 8.8, p<0.01). No significant effect was found between composite DA score and ASD traits (r^2= .02, F (1, 78) = 1.3, p=0.257).

Two outlier's above three standard deviations from the mean were identified in SA scores by analysing descriptive statistics. When excluding outliers from linear regressions; SA score then explained a borderline significant amount of variance in ASD traits (r^2= .05, F (1, 76) = 3.9, p=00.53), however outliers were chosen to be included in further analysis, as it's likely that these scores were true representations of the participants abilities.

3.2.2 Semi-partial correlation controlling for age

Pearson's correlation coefficient (r) showed a significant negative relationship between age and SA (r(80) = -.482, p<0.001 (1-tailed)), demonstrating that SA improved with age. Because of this a semi-partial correlation is appropriate to control for age, which demonstrated there was still a significant effect of SA when controlling SA for age. Age didn't need to be controlled for the ASD trait measures as age is taken into account by teachers when completing SDQ's.

3.2.3 Tracking, Cue-detection and composite ASD traits

Due to no significant relationship between DA and composite ASD traits, further linear regressions were conducted to examine whether one part of the task (e.g. tracking) was having an effect that was being masked by the other (e.g. cue-detection). The tracking (TE) and cue-detection (CD) components of each task were analysed separately for both DA and SA, with composite ASD traits. These are displayed in tables 3 and 4 respectively.

Table 3. Regressions to show the variance in composite ASD traits explained by divided attention measures of TE and CD.

Measure	TE (DA)	CD (DA)
Composite ASD traits	r^2= .09, F (1,78) = .60, p= .441	r^2= .02, F (1,78) = 1.21, p= .274

This signifies that neither measure of DA explains a significant amount of variance in composite ASD traits.

Table 4. Regressions to show the variance in composite ASD traits explained by sustained attention measures of TE and CD.

Measure	TE (SA)	CD (SA)
Composite ASD traits	r^2= .08, F (1,78) = 6.54, p<.05	r^2= .10, F (1,78) = 8.57, p<.01

Both tracking and cue detection scores under sustained attention conditions explained a significant amount of variance in ASD traits, such that tracking explained 8%, and cue-detection explained 10% of the variance.

3.2.4 Divided Attention, Sustained Attention and ASD trait subscales

The above findings signify a positive relationship between composite ASD traits and SA, but no relationship between composite ASD traits and DA; thus further linear regressions were performed to explore how much variance in the three separate ASD traits (reverse pro-social behaviour, peer problems and emotional symptoms) can be explained by the two attention measures (DA and SA). These are reported in table 5.

Table 5. Regressions to show the variance in individual ASD traits explained by attention measures.

Measure	Composite DA score	Composite SA score
Reverse pro-social behaviour	r^2= .055, F (1,78) = 4.53**	r^2= .093, F (1,78) = 7.98**
Peer problems	r^2= .001, F (1,78) = .048	r^2= .084, F (1,78) = 7.19**
Emotional symptoms	r^2= .001, F (1,78) = .05	r^2= .003, F (1,78) = .231

**= p≤0.05, (2-tailed)

Both attention measures explain a significant amount of variance in the reverse pro-social behaviour scale, with DA explaining around 6% and SA explaining around 9% of the variance. The composite SA measure also explains a significant amount (8%) of variance in the peer problems scale.

Semi-partial correlations were conducted for all significant results above, controlling SA for age. They all still explained a significant amount of variance when controlling for age.

3.2.5 Tracking, Cue-detection and ASD trait subscales

Due to the above findings additional linear regressions were performed to see which aspects of the attention measure (i.e. tracking and cue-detection) accounted for the variance in the two ASD trait subscales shown to have a significant effect with DA or SA. Regressions are shown for DA and SA in table 6 and 7 respectively.

Table 6. Regressions to show variance in ASD trait subscales explained by DA measures of TE and CD.

Measure	TE (DA)	CD (DA)
Reversed pro-social behaviour	r^2= .019, F (1,78) = 1.48	r^2= .06, F (1,78) = 4.96**

**= p≤0.05, (2-tailed)

Table 6 shows only cue-detection aspects of the DA measure explain a significant amount of variance in the reversed pro-social behaviour scale. Furthermore significant positive correlations between the cue-detection aspect of the divided attention measure and reversed pro-social behaviour (Table 2) suggests that as pro social traits decrease (higher

reverse pro-social scores), performance decrement on task increased between single and dual task conditions but only for the cue-detection part of task, as indicated in table 6.

Table 7. Regressions to show variance in ASD trait subscales explained by TE and CD sustained attention measures.

Measure	TE (SA)	CD (SA)
Reversed pro-social behaviour	r^2= .8, F (1,78) = 6.79**	r^2= .78, F (1,78) = 6.57**
Peer problems	r^2= .076, F (1,78) = 6.44**	r^2= .066, F (1,78) = 5.53**

**= p≤0.05, (2-tailed)

Both sustained attention tasks explain a significant amount of variance in the reversed pro-social and peer problems scales. Pearson's correlation coefficient (r) depicts a significant correlation (Table 2), suggesting that as pro-social behaviour decreases (higher reverse pro-social score) and peer problems increase, scores on both tasks of sustained attention also increase (indicating worse performance).

4. Discussion

4.1 Summary of Findings

This study explored the relationship between primary school children's sustained and divided attentional abilities and ASD traits as measured on a continuum using the SDQ.

Initially the results revealed a relationship between composite ASD traits and sustained attention but not divided attention. Only the SA measure significantly correlated with the composite ASD trait measure; linear regressions suggested that the SA measure explained a significant amount of variance in the composite ASD trait measure; however the DA measure did not. Due to a significant relationship between age and SA, a semi-partial correlation was carried out which demonstrated there was still a significant effect of SA when controlling for age.

Further Linear regressions were conducted to investigate the relationship between constituent parts (tracking and cue-detection) of the attention measures with the composite ASD trait measure. This signified that both tracking and cue-detection tasks under sustained attention conditions explained a significant amount of variance in ASD traits; however there were no significant effects for either part of DA task.

Due to the fact that preliminary analysis revealed a correlation between both sustained and divided attention measures and total SDQ score, suggesting there may be a relationship that isn't being captured by the composite ASD trait measure; further linear regressions were employed to explore how much variance in the three separate ASD trait subscales could be explained by the attention measures. Both attention measures explained a significant amount of variance in the reversed pro-social behaviour scale; the SA measure explained a significant amount of variance in the peer problems scale; and neither measure explained a significant proportion of the emotional symptoms scale. This was still the case when semi-partial correlations were employed to control for age on attention measures.

Additional linear regressions were employed as before to examine the relationship between constituent parts of both attention measures with these ASD trait subscales. Only the cue-detection aspect of the DA measure explained a significant amount of variance in the

reversed pro-social behaviour scale. Both SA measures explained a significant amount of variance in the reversed pro-social and peer problems scales.

Finally the results revealed that the attention measure was unsuitable for children under the age of 7 years old.

4.2 Implications

Initially the results suggest that the more ASD traits a child possesses, as indicated by the composite ASD trait measure, the poorer their ability to SA. Furthermore, no relationship between DA and the composite ASD trait measure was established. This contradicts the results found by the majority of previous research that suggest children with ASD have no deficits of SA (Buchsbaum *et al,* 1992; Noterdaeme *et al,* 2001; Johnson$_b$ *et al,* 2007), but difficulties in ability to DA (Althaus, 1996; Koldewyn *et al,* 2012; Swaab-Barneverd, 1998).

One reason for contrasting results may be partly due to 'floor effects', as Participants who displayed more ASD traits may have performed particularly poor on the SA task such that performance couldn't get much worse on DA tasks. Alternatively it may be due to the present study summing up the subscales of the SDQ that have been validated by previous research as representing ASD traits (Iizuka *et al,* 2010; Russell *et al,* 2012, Posserud *et al*, 2008), into a composite ASD trait score. When analysing the separate subscales of the ASD traits (pro-social behaviour, peer problems and emotional symptoms), results suggest that comorbid attention problems may relate to certain aspects of ASD traits but not others; which may be hidden when utilising the composite ASD trait measure. Results from the current study suggest that the low pro-social behaviour trait of ASD may be more related to poor attention than the other ASD trait subscales of the SDQ. It makes sense to suggest that if there is a relationship between low pro-social behaviour and poor attention that a child with ASD who displays poor social behaviour such as 'not helping someone who is hurt or feeling ill' may possibly behave like this partly because they are not paying attention to the situation (Kanner, 1943). This is in line with previous research that states it's difficult to understand attention deficits in ASD independent of their association with poor social behaviour (Kope *et al*, 2001). Thus although emotional symptoms and peer problems may be traits of ASD, they may not have a strong relationship with any attentional deficits that may be present.

Alternatively ASD traits may be effectively captured by the pro-social scale of the SDQ alone, in the absence of any increased predictive value coming from the other two subscales. Evidence for this stems from research by Goodman (1997) which proposes that the pro-social subscale of the SDQ explains more variance in ASD than the other scales, and furthermore has shown to be strongly associated with an ASD diagnosis in the ALSPAC cohort (Russell *et al,* 2012). Likewise previous research by Russell *et al* (2010) found a 'four fold increase in the odds of an ASD diagnosis for decreasing pro-social behaviour'. Although the exact SDQ scales used to assess ASD traits often varies between studies (Afshari, 2012).

Despite this, ASD does not manifest a primary behaviour issue relating to attentive capacities. Thus although results from this study have shown slightly different interpretations of results depending on how ASD traits are scored, the study does not aim to validate one SDQ scoring method for ASD traits over another. The key finding is however, that attention capacity does appear to be poorer in those children who display greater ASD traits (in particular low pro-social behaviour); suggesting attention is possibly a comorbid deficit in ASD alongside the defining feature of social and communication impairments. This replicates results from previous research that suggests there is a relationship between ASDs and attentional difficulties (Sturm et al 2004), including a deficit in the ability of children with ASD to DA across a specific modality (Alais *et al,* 2006; Wainwright-Sharp & Bryson, 1993; Pierce *et al,* 1997). Although the majority of past research implies there is no deficit in the ability to sustain attention in ASD, more recent research is consistent with the present finding that children with ASD do have difficulties sustaining attention (Corbett *et al*, 2006; Cristakou *et al,* 2013). As both sustained and divided attention have a relationship with academic achievement (Gordon *et al*, 1994); deficits in these areas may help explain why children with ASD often show poor performance in school (Dickerson *et al,* 2003). This has possible implications for providers of education, in terms of providing strategies and assistance to ensure these children can fulfill their academic potential. In addition to this the present study suggests that these attentional difficulties exist along a continuum of ASD traits; as the number of ASD traits a child shows as rated by teachers on the SDQ increases (in particular low pro-social behaviour), a decrease in the child's ability to sustain and divide attention is demonstrated.

The findings from the present study may have implications for the ways in which ASDs are diagnosed. Currently the DSM-IV-TR (2000) has three categories of impairments of which a child must display a stipulated amount of symptoms from each in order to meet a diagnosis of ASD. The three categories are: impairments in social interaction; impairments in communication; and restricted, repetitive and stereotyped patterns of behaviour, interests and activities (DSM-IV TR; American Psychiatric Association, 2000). No symptoms of attention deficits are included in this diagnosis, despite past research and definitions acknowledging that it may be an underlying problem in ASDs. For example Kanner's (1943) early description proposed that attention deficits were a symptom of 'autism', and Bolte *et al*, (1999) suggested that attention problems were a 'striking' feature of 'autism'.

When a clinician is attempting to diagnose a child that displays both ASD and attention problems complications often arise; as the DSM-IV-TR precludes a dual-diagnosis of both ASD and Attention Deficit Hyperactivity Disorder (ADHD). This has implications for the way in which the child is treated, as they may not receive the medication and other treatments that may benefit them. Kolevzon (2007) reports clinical trials that have demonstrated the effectiveness of ADHD medication to manage attention deficits in individuals with ASD. Due to these findings and previous studies that propose possible comorbidity between ASD and ADHD (Goldstein *et al,* 2004), it may be in the child's best interest to permit a dual-diagnosis if they display both ASD traits and attention deficits; in order for them to acquire the most beneficial treatment. Treatment for ASD could be further improved by varying the salience of the treatment offered depending on the severity of ASD, as the present study demonstrates that ASD traits exist along a continuum although the DSM-IV-TR currently acknowledges ASDs as single disorders.

In addition, the current findings may aid in earlier identification of ASDs; if a parent or teacher notices attention problems in a child alongside social problems it may provide an earlier indicator of difficulties, which may lead to an earlier referral for the child to be assessed by a clinician for ASD. Potentially attentional ability may be useful as a research tool; the attention measure used in this study is able to objectively assess sustained and divided attention, thus perhaps it may be a quicker and easier tool to aid in the diagnosis of ASD traits, as it is much harder to objectively measure the defining features of social or communication impairments which usually requires more complex measurements.

4.3 Strategy adoption during dual-tasking in children displaying higher ASD traits

The finding that fewer pro-social ASD traits has a significant relationship with poorer performance on the cue detection task but not the tracking task under dual task conditions suggests that these children who displayed fewer pro-social ASD traits were prioritising the tracking task over the shape spotting task in the combined condition. This implies they were more interested in sustaining attention on the single tracking task than trying to divide attention between the two tasks; thereby detrimentally affecting performance on the cue detection aspect of the task. This finding contradicts past research that has demonstrated that during dual-task conditions the requirement to divide attention hinders manual visuo-motor performance (Kemper *et al,* 2010), which in turn would be expected to hinder tracking. Specifically, the current study suggests that children that display higher levels of ASD traits may be more focused on mastering hand movements required for the tracking task than trying to focus on both tasks at once. This is in line with previous research that suggests ASD individuals may have proprioceptive deficits (Weimer *et al,* 2001) which affect their fine motor skills leading to difficulties in tasks such as handwriting (Fuentes et al 2009); this may partly explain the finding in the present study as the hand-movements required for the tracking task resemble those needed for handwriting, thus if they struggle with these movements they may focus more of their attention on trying to get the movement right, irrespective of the other task. This may in turn provide additional insights into the difficulties children with ASD face in a classroom setting when trying to divide attention between specifically writing and paying attention to something else (e.g. listening to teacher); however the present study focused on modality specific interference during dual tasking so this exact supposition cannot be verified.

4.4 The relationship between attentional abilities and ASD traits

Even though the current study has provided some promising results, it is unable to yield a cause and effect relationship. It may be that the social and communication impairments, as well as attentional deficits seen in ASD exist alongside each other. Alternatively one of these difficulties may cause the other. This may be the case as a failure to sustain attention may cause problems when communicating, as the child may not be able to engage in a conversation or game long enough to be able to fully participate or be accepted by the other children. Likewise a deficit in the ability to divide attention may lead a child with ASD

to fail to pick up on the different social and non-verbal cues that guide inter-personal interactions, as well as being unable to concentrate on social situations that require attention to be paid to numerous stimuli (Kolevzon, 2007). On the other hand it could be that having social and communication impairments results in poor attention skills, as these individuals are less likely to be involved in social situations and conversations which require them to engage their attention; thus they may have less chance to improve their attention skills.

As previously discussed it is difficult to understand attention deficits in children with ASD traits independent of the social difficulties they display. There is support for the proposition that attention deficits may contribute to the poor social behaviour seen in ASD individuals. For example Adrien *et al* (1993) found that attention problems observed during the first year of a child's life were indicative of increased chances of obtaining an ASD diagnosis one year later. Recently Elsabbagh *et al* (2013) further suggested that children who develop autism typically display deficits in visual attention from the first year of life. In addition, Althaus (1996) proposed the idea that a deficit of DA in ASD children may underlie their difficulties to adapt to unfamiliar situations; as adaptation to unfamiliar situations requires novel information and existing information about the environment to be interpreted, recognized and processed simultaneously. This is in line with Dawson *et al* (2012) who hypothesized that reduced attention has negative consequences for social and language development and learning, affecting the experience dependent circuitry utilized by these domains.

In addition children with well-established attention deficits such as those with ADHD often develop poor social relationships. Evidence for this is provided by Kane (2007) who studied ADHD children; he concluded that the difficulties these children had in sustaining attention led to rejection from other peers as they often got bored and forgot rules of games due to inattention; this is likely to lead to withdrawal and feelings of low self-esteem (Hodgens *et al,* 2000). This suggests that attention deficits may have a detrimental effect on social skills.

These findings propose that attentional abilities could be used as a potential indicator of ASD traits. Improving attention in children with ASD traits may help improve their social and communication skills that manifest themselves as the defining features of ASD.

4.5 Limitations

There are some limitations in the present study. Despite the pilot study revealing the demands of the attention measure were too difficult for children younger than 7 years of age to comply with, some of the older children still struggled with the nature of the task. For example during the divided attention condition, right handed participants often lifted the pen off the screen when they were tracking the top left-hand dot in order to see the cue box which was obstructed by their hand; left handed children showed similar behaviour when tracking the top right-hand dot. In addition, the participants were not able to rest their hand on the tablet to provide stability which they normally would when writing on paper, which could have affected accuracy of hand movements.

In terms of data collection, although standardised instructions were used, there were 11 different researchers which may have led to participants receiving slightly different variations of instructions. Furthermore the testing took place in an area of the school that was open plan and often noisy at break times. This may have affected attention as Schmidt *et al* (2008) proposed a relationship between attention and environmental noise which could be indirectly effective in decreasing or increasing attention.

With regards to analysing the data, the composite measure of sustained and divided attention may be too broad. Further research may benefit from looking at specific measures of each task, for example specifically individual variability (IV) in performance; as previous research established that IV alone provides information about attentiveness (Hill *et al,* 2012). The SDQ, whilst being a validated measure of behaviour relies on subjective interpretations of difficulties by teachers. This may result in the ASD traits being scored differently as teacher's perceptions of what constitutes as a difficulty may be varied.

4.6 Future Directions

Future research could aim to develop the attention measure, and work towards a clearer understanding of the associations between attention and ASD traits. Currently it's a very subjective decision by a teacher or parent to refer a child to a psychiatrist for suspected ASD. In the future the attention measure could be used to establish unambiguously the children who require further assessment for ASD traits. As it has been proposed that a

potentially large number of children get excluded from school due to undiagnosed autism (Skuse *et al,* 2010); a readily available measure like the attention task could be of use in classrooms where it is easy for the child to carry out simple tests that may highlight attention problems associated with ASD traits. Potentially this could help decrease the number of undiagnosed cases of children with autism (Fombonne, 2009). This would be particularly useful if the measure could be adapted for use on younger children so screening could take place as early as possible.

The attention measure could potentially be a useful tool for the 'Born in Bradford' study if it was administered to each child the same as the C-KAT motor battery already is. As this cohort is known to have a high prevalence of undiagnosed genetic disorders, this tool could assist in highlighting those children with attention problems which could indicate possible ASD traits; thus allowing early intervention and screening to take place to enable the children to receive the assistance and treatment they require.

Further research could test to see if repeated performance on the visuo-motor attention task improves attentional abilities in children displaying more ASD traits, as Afshari (2012) showed that perceptual-motor training for children with autism increased their attention abilities. This could be useful as findings from past research suggest that if attention can be improved in school, an increase in school performance may also be observed (Rabiner *et al,* 2010). Educational adaptations may be required to compensate for the possible attention deficit in ASD; seating children with ASD nearer to the teacher and only asking them to do one thing at a time may be one way in which additional help could improve their educational outcome (Mayes *et al,* 2000).

Finally it would be useful to replicate the study using a more thorough representation of ASD traits such as the SCQ (Rutter *et al,* 2003) or ASSQ (Ehler *et al,* 1999), as although the SDQ subscales used in the present study have been verified to represent some ASD traits (Iizuka *et al,* 2010; Russell *et al,* 2012), they don't capture all traits associated with ASD; such as behaviours that are stereotyped and repetitive, language skills and compulsive behaviours.

4.7 Conclusions

The present study examined sustained and divided attentional abilities of children along a continuum of autistic spectrum disorder traits. An association between ASD traits and sustained and divided attention was found, however this attention deficit may be captured by certain ASD traits more than others; in particular pro-social behaviour. Overall the results suggest that attention capacity does appear to be poorer in those children who display greater ASD traits; suggesting attention problems are possibly a comorbid deficit in ASD alongside the defining feature of social and communication impairments. The results may have implications for the ways ASDs are assessed and diagnosed, as they imply that permitting a dual-diagnosis of ADHD alongside ASD may benefit the child by allowing access to medication if required. The results may also have implications for education provider's strategies to assists children that display ASD traits, as sustained and divided attention have a relationship with academic achievement. Further research is required to better understand the relationship between attention and ASD traits; with the attention measure being a potential future tool to help identify children at risk of ASDs early in life.

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Appendices

Appendix A. DSM-IV-TR Diagnostic criteria for ASD

299.00 Autistic Disorder

A. A total of six (or more) items from (1), (2) and (3), with at least two from (1), and one each from (2) and (3):

(1) qualitative impairment in social interaction, as manifested by at least two of the following:
   (a) marked impairment in the use of multiple nonverbal behaviours such as eye-to-eye gaze, facial expression, body postures, and gestures to regulate social interaction
   (b) failure to develop peer relationships appropriate to developmental level
   (c) a lack of spontaneous seeking to share enjoyment, interests, or achievements with other people (eg, by a lack of showing, bringing, or pointing out objects of interest)
   (d) lack of social or emotional reciprocity

(2) qualitative impairments in communication as manifested by at least one of the following:
   (a) delay in, or total lack of, the development of spoken language (not accompanied by an attempt to compensate through alternative modes of communication such as gestures or mime)
   (b) in individuals with adequate speech, marked impairment in the ability to initiate or sustain a conversation with others
   (c) stereotyped and repetitive use of language or idiosyncratic language
   (d) lack of varied, spontaneous make-believe play or social imitative play appropriate to developmental level

(3) restricted repetitive and stereotyped patterns of behaviour, interests and activities, as manifested by at least one of the following:
   (a) encompassing preoccupation with one or more stereotyped and restricted patterns of interest that is abnormal either in intensity or focus
   (b) apparently inflexible adherence to specific, non-functional routines or rituals
   (c) stereotyped and repetitive motor mannerisms (eg, hand or finger flapping or twisting, or complex whole body movements)
   (d) persistent preoccupation with parts of objects

B. Delays or abnormal functioning in at least one of the following areas, with onset prior to age 3 years: (1) social interaction, (2) language as used in social communication or (3) symbolic or imaginative play

C. The disturbance is not better accounted for by Rett's Disorder or Childhood Disintegrative Disorder

299.80 Asperger's Disorder

A. Qualitative impairment in social interaction, as manifested by at least two of the following:

(1) marked impairment in the use of multiple nonverbal behaviours such as eye-to-eye gaze, facial expression, body postures, and gestures to regulate social interaction
(2) failure to develop peer relationships appropriate to developmental level
(3) a lack of spontaneous seeking to share enjoyment, interests, or achievements with other people (eg, by a lack of showing, bringing or pointing out objects of interest to other people)
(4) lack of social or emotional reciprocity

B. Restricted repetitive and stereotyped patterns of behaviour, interests, and activities, as manifested by at least one of the following:

(1) encompassing preoccupation with one or more stereotyped and restricted patterns of interest that is abnormal either in intensity or focus

(2) apparently inflexible adherence to specific, non-functional routines or rituals
(3) stereotyped and repetitive motor mannerisms (eg, hand or finger flapping or twisting, or complex whole-body movements)
(4) persistent preoccupation with parts of objects

C. The disturbance causes clinically significant impairment in social, occupational, or other important areas of functioning.

D. There is no clinically significant general delay in language (eg, single words used by age 2 years, communicative phrases used by age 3 years).

E. There is no clinically significant delay in cognitive development or in the development of age-appropriate self-help skills, adaptive behaviour (other than in social interaction), and curiosity about the environment in childhood.

F. Criteria are not met for another specific Pervasive Developmental Disorder or Schizophrenia.

299.80 Pervasive Developmental Disorder Not Otherwise Specified (Including Atypical Autism)

This category should be used when there is a severe and pervasive impairment in the development of reciprocal social interaction associated with impairment in either verbal or nonverbal communication skills or with the presence of stereotyped behaviour, interest, and activities, but the criteria are not met for a specific Pervasive Developmental Disorder, Schizophrenia, Schizotypal Personality Disorder, or Avoidant Personality Disorder. For example, this category includes 'atypical autism' – presentations that do not meet the criteria for Autistic Disorder because of late age at onset, atypical symptomatology, or sub threshold symptomatology, or all of these.

Appendix B. ICD-10 Diagnostic criteria for ASD

F84 Pervasive developmental disorders

A group of disorders characterized by qualitative abnormalities in reciprocal social interactions and in patterns of communication, and by a restricted, stereotyped, repetitive repertoire of interests and activities. These qualitative abnormalities are a pervasive feature of the individual's functioning in all situations.

Use additional code, if desired, to identify any associated medical condition and mental retardation.

F84.0 Childhood autism

A type of pervasive developmental disorder that is defined by: (a) the presence of abnormal or impaired development that is manifest before the age of three years, and (b) the characteristic type of abnormal functioning in all the three areas of psychopathology: reciprocal social interaction, communication, and restricted, stereotyped, repetitive behaviour. In addition to these specific diagnostic features, a range of other nonspecific problems are common, such as phobias, sleeping and eating disturbances, temper tantrums, and (self-directed) aggression.

Autistic disorder Infantile:

- autism
- psychosis

Kanner's syndrome

Excludes: autistic psychopathy (F84.5)

F84.1 Atypical autism

A type of pervasive developmental disorder that differs from childhood autism either in age of onset or in failing to fulfil all three sets of diagnostic criteria. This subcategory should be used when there is abnormal and impaired development that is present only after age three years, and a lack of sufficient demonstrable abnormalities in one or two of the three areas of psychopathology required for the diagnosis of autism (namely, reciprocal social interactions, communication, and restricted, stereotyped, repetitive behaviour) in spite of characteristic abnormalities in the other area(s). Atypical autism arises most often in profoundly retarded individuals and in individuals with a severe specific developmental disorder of receptive language.

Atypical childhood psychosis
Mental retardation with autistic features

Use additional code (F70-F79), if desired, to identify mental retardation.

F84.5 Asperger's syndrome

A disorder of uncertain oncological validity, characterized by the same type of qualitative abnormalities of reciprocal social interaction that typify autism, together with a restricted, stereotyped, repetitive repertoire of interests and activities. It differs from autism primarily in the fact that there is no general delay or retardation in language or in cognitive development. This disorder is often associated with marked clumsiness. There is a strong tendency for the

abnormalities to persist into adolescence and adult life. Psychotic episodes occasionally occur in early adult life.

Autistic psychopathy
Schizoid disorder of childhood

F84.8 Other pervasive developmental disorders
F84.9 Pervasive developmental disorder, unspecified

Appendix C. Example Strengths and Difficulties Questionnaire, 4-16 years

For each item, please mark the box for Not True, Somewhat True or Certainly True. It would help us if you answered all items as best you can even if you are not absolutely certain or the item seems daft! Please give your answers on the basis of the child's behaviour over the last six months or this school year.

Child's Name .....Male/Female

Date of Birth.....

	Not True	Somewhat True	Certainly True
Considerate of other people's feelings (ps)	☐	☐	☐
Restless, overactive, cannot stay still for long	☐	☐	☐
Often complains of headaches, stomach-aches/sickness (e)	☐	☐	☐
Shares readily with other children (treats, toys, pencils) (ps)	☐	☐	☐
Often has temper tantrums or hot tempers	☐	☐	☐
Rather solitary, tends to play alone (pp)	☐	☐	☐
Generally obedient, usually does what adults request *	☐	☐	☐
Many worries, often seems worried (e)	☐	☐	☐
Helpful if someone is hurt, upset or feeling ill (ps)	☐	☐	☐
Constantly fidgeting or squirming	☐	☐	☐
Has at least one good friend (pp)*	☐	☐	☐
Often fights with other children or bullies them	☐	☐	☐
Often unhappy, down-hearted or tearful (e)	☐	☐	☐
Generally liked by other children (pp)*	☐	☐	☐
Easily distracted, concentration wanders	☐	☐	☐
Nervous/clingy in new situations, easily loses confidence (e)	☐	☐	☐
Kind to younger children (ps)	☐	☐	☐
Often lies or cheats	☐	☐	☐
Picked on or bullied by other children (pp)	☐	☐	☐
Often volunteers to help others (parents/teachers) (ps)	☐	☐	☐
Thinks things out before acting *	☐	☐	☐
Steals from home, school or elsewhere	☐	☐	☐
Gets on better with adults than with other children (pp)	☐	☐	☐
Many fears, easily scared (e)	☐	☐	☐
Sees tasks through to the end, good attention span *	☐	☐	☐

Signature…… Date…….

Parent/Teacher/Other (please specify :)

Thank you very much for your help

Attentional Ability in Autistic Trait Children

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Introduction

Autism Spectrum Disorder (ASD) - typically characterised by social deficits, repetitive behaviours and communication difficulties.

Many individuals with ADHD also have ASD (*Gillberg et al 1987)*

Attention is often referred to as the allocation of processing resources *(Anderson et al 2004).*

In respect to visual attention, there are two main categories:

1. Sustained visual attention (SA)
2. Divided visual attention (DA)

Some children with ASD have exceptional ability to sustain attention on single tasks. However research has shown they often have problems dividing attention between tasks *(Mann et al 2003)*

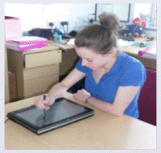
The current study explores the relationship between sustained and divided visual attentional abilities and ASD traits across an opportunity sample of 250 children from a school in Bradford.

Hypothesis = There will be a negative correlation between ASD sub scale scores and scores on the DA task. There will no correlation between ASD scores and scores on the SA task.

Method

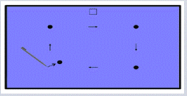
•**Participants**: Healthy children aged 7-11 years were recruited from a local primary school affiliated with the Born in Bradford cohort. (n=250).

•**Materials:** The experimental tasks were produced using custom made software, 'Kinelab' (Culmer et al. 2009), and performed on a touch screen tablet. Participants used a pen shaped digitised stylus as an input device to complete the tasks.

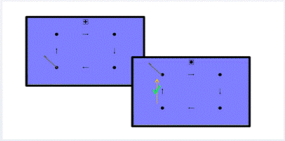


•**Procedure:** The Attention task had three components taking a total of approximately 12-15 minutes; each task was preceded by a 10/15 second practice trial to familiarise the children with the task/apparatus.

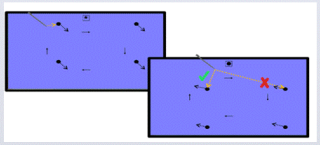
•**1)** ***Tracking (Sustained Attention)***: Participants were required to follow/track the path of a target (dot) continuously for 3 minutes using their stylus.



•**2)** ***Cue detection (Divided Attention)***: Participants were instructed to move their stylus clockwise around the screen to the next dot when a cross followed by a circle flashed up in a central cue box.



•**3)** ***Tracking & Cue Detection Combined task (Divided Attention)***. This task combined Task 1 & Task 2 and required participants to track one of four simultaneously moving targets moving to the next target when the appropriate cue (cross followed by circle) appeared.



Results

Pilot study – Showed that the task was unsuitable for children under 7 years old

We expect a **negative correlation** between scores on the **autism** subscale of the SDQ and scores on the **attention** measure.

We don't expect children with high scores on the autism subscale to have significant problems with sustained attention.

We expect children with high autism scores to trade off performance on the cue detection task for the tracking task

Preliminary Conclusions

•The Kinelab task provided an accurate measure of SA & DA

•Following the pilot study we can conclude the task would require modifications in order to be used as a screening tool in children under 8 years.

Future Directions

•If a link is found between high autistic traits and divided attention scores, the task could be used in the future to aid screening for ASD.

•This could help inform school practices ie. more one on one support when DA is required to ensure this is not detrimental to the academic performance of children with ASD

•Future research could test to see if repeated performance on the task improved attentional abilities

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Appendix E. Supervision Diary

Weekly meetings were held with [redacted], details of which are below:

date	time given	topics discussed and actions to be taken
8/10/12	1 hour	First meeting – introductions with group. Overview of topic area
15/10/12	1 hour	Discussed background to attention – previous studies and current findings
22/10/12	1 hour	Explanation of C-Kat. Able to take laptops away to practice with at home.
29/11/12	1 hour	Discussed SDQ and how we can measure attention
12/11/12	1 hour	Discussed different attention tasks and things that we may want to explore that may have a relationship with task e.g. Autism
19/11/12	1 hour	Discussed possible research questions and associations with sustained and divided attention.
26/11/12	1 hour	BIB training session.
05/02/13	1 hour	Discussed method and things to include. Discussed descriptions of tasks and demographics of participants. Draft abstract and method for next session.
12/02/13	1 hour	Talked about basic things to include in intro. Discussed potential of comorbidity between ADHD and ASD – framework. Outline of intro for next session.
19/02/13	1 hour	Discussed problems with looking at between-group samples and why our population based sample may be better.
26/02/13	1 hour	How social limitation in autism may be associated with attention. Possible future directions. Planned poster presentations
5/03/13	1 hour	Final questions about method and intro. Talked about using regression in analysis.
15/03/13	1 hour	Discussed possible statistical analysis that could be conducted e.g. regression. Received email with excel spread-sheet containing raw data.

Student's signature _____ Supervisor's signature _____

Appendix F. Raw data and SPSS output on CD