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An exploration of cognitive ability factors, anxiety and the physiological experience in children with Autism Spectrum Disorder (ASD)

by

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ABSTRACT

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The aims of the present review were to examine whether cognitive ability factors, including measures of verbal and nonverbal ability are associated with anxiety symptoms in children and young people with Autism Spectrum Disorder (ASD). A systematic search of the literature yielded 17 studies, which included participants aged between 15 months and 18 years with diagnoses of ASD or Pervasive Developmental Disorders- Not Otherwise Specified (PDD-NOS). It was found that verbal and nonverbal IQ were positively associated with increased rates of anxiety in individuals with ASD. However these relationships only appear to hold true for children with intellectual levels below the normal range (i.e one standard deviation below the mean). Implications of these findings are discussed and different developmental pathways are considered which describe the role of verbal and nonverbal ability in the development and expression of anxiety symptoms. This review highlights several methodological limitations within the literature, in particular highlighting difficulties with the assessment of anxiety in individuals with ASD which makes it difficult to draw conclusions about the prevalence and phenomenology of anxiety in this population.

The empirical paper examines associations between cognitive ability factors (verbal and nonverbal ability) and anxiety in a group of secondary aged adolescents (n=9) with high functioning autism (HFA) and their typically developing peers (n=7). The study used an experience sampling technique to carefully monitor anxiety across two school days. To address potential difficulties in assessment a multi-modal assessment technique was used to triangulate anxiety data. This assessment included questionnaire measures, self-report and the concurrent collection of salivary cortisol as a physiological indicator of anxiety. In this sample, no correlations were observed between measures of verbal or nonverbal ability and anxiety suggesting that associations between cognitive ability and

anxiety do not hold true for adolescents with ASD within the normal range for intellectual functioning. Moreover, in contrast to previous research there were no significant differences between anxiety prevalence or severity between groups as rated by questionnaire measures. It was found that adolescents with ASD experienced similar levels of physiological arousal across the school day to their typically developing (TD) peers. However differences were observed in experience sampled data indicating that adolescents with ASD interpret these underlying bodily cues differently to their peers. These findings help to develop our understanding of the physiological experience of anxiety in adolescents with HFA and also inform future research into the assessment of anxiety in this population.
Key words: anxiety, autism, cognitive ability, verbal ability, nonverbal ability

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DECLARATION OF AUTHORSHIP

I, Matthew Brown declare that the thesis entitled '**An exploration of cognitive ability factors, anxiety and the physiological experience in children with Autism Spectrum Disorder (ASD)**' and the work presented in the thesis are both my own, and have been generated by me as the result of my own original research. I confirm that:

- this work was done wholly or mainly while in candidature for a research degree at this University;
- where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
- where I have consulted the published work of others, this is always clearly attributed;
- where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
- I have acknowledged all main sources of help;
- where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
- none of this work has been published before submission.

Signed: ……..

Date:…….

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Definitions and Abbreviations

ASD	Autism Spectrum Disorder
PDD-NOS	Pervasive Developmental Disorders- Not Otherwise Specified
HFA	High Functioning Autism
TD	Typically Developing
GAD	Generalised Anxiety Disorder
ADOS	Autism Diagnostic Observation Schedule
ADI-R	Autism Diagnostic Interview-Revised
BISCUIT	Baby and Infant Screen for Children with autism Traits
WASI	Wechsler Abbreviated Scale of Intelligence
WISC	Wechsler Intelligence Scale for Children
BDI	Batelle Development Inventory
CBCL	Child Behaviour Checklist
VABS	Vineland Adaptive Behaviour Scales
MSEL	Mullen Scales of Early Learning
RPM	Raven's Progressive Matrices
MHVS	Mill Hill Vocabulary Scale
SCAS	Spence Children's Anxiety Scale
SDQ	Strengths and Difficulties Questionnaire

Chapter 1: Review paper

What cognitive ability factors are associated with anxiety in ASD? A systematic review of the research

What cognitive ability factors are associated with anxiety in ASD? A systematic review of the research

Introduction

Anxiety Disorders

Anxiety disorders are the most prevalent form of mental distress for young people in the UK, with increased prevalence in girls (Green, McGinnity & Meltzer, 2005). Clinical rates indicate that around 3.1% of boys and 4.3% of girls in the UK are reported to experience some form of recognisable anxiety disorder (Green et al. 2005). The Diagnostic and Statistical Manual of Mental Disorders- 5 (DSM-5; American Psychiatric Association; APA, 2013) outlines several anxiety disorders that are diagnosed in children and adolescents. These disorders link to general anxieties or worries, or anxiety and fear linked to specific objects or situations and result in physical, psychological, cognitive and emotional symptoms. Diagnostic criteria for generalised anxiety disorder (GAD), for example, include excessive worry or apprehensive expectation occurring over a period of at least 6 months and where the symptoms cause clinically significant distress (APA, 2013). Other specific anxiety disorders include agoraphobia (fear of public or open spaces), specific phobia (fear of a specific stimulus or situation), social anxiety disorder and social phobia (fear of social or performance situations), panic attack (a discrete period of intense fear or discomfort) and separation anxiety disorder (fear of separation from attachment figure).

Anxiety disorders peak during adolescence, with 3.6% of boys and 5.2% of girls aged 11-16 diagnosed with some form of anxiety disorder (Green et al. 2005). Official figures in the UK indicate that in the typically developing (TD) population, the most common form of clinically diagnosed anxiety disorders were reported as specific phobia (0.9% prevalence), followed by generalised anxiety (0.8%). The lowest reported prevalence is for panic disorder and agoraphobia (0.2% and 0.1% respectively) (Green et al. 2005). When looking at non-clinical classifications, reported prevalence rates are higher still. For example, Costello, Egger, Copeland, Erkanli and Angold, (2011) estimated prevalence at 10.2% for any anxiety disorder in

children aged 8-16 from a meta-analysis of 55 data sets. In this report, the most prevalent forms of anxiety were recorded as specific phobia (5.4%), social phobia (3.6%) and separation anxiety disorder (2.6%).

While genetic factors have been argued to account for a large proportion of anxiety (Bergen, Gardner & Kendler, 2007; Trzaskowki, Zavos, Haworth, Plomin & Eley, 2012), researchers have also identified environmental risk factors which can further account for individual differences in expression. For example, higher levels of stress and family conflict (Hammen, Brennan & Shih 2004); parenting styles and attachment type (Feng, Shaw & Silk 2008; Shamir-Essakow et al. 2005) and poor peer relationships (de Matos, Barrett, Dadds & Shortt, 2003) are all positively associated with anxiety. These environmental factors are argued to interact with biological and child factors such as temperament (Shamir-Essakow et al. 2005), reflecting an individual's susceptibility to anxiety.

The development of anxiety may be, at least in part, due to distorted beliefs about the level of danger or threat of a given situation. For example, Matthews and Mackintosh (1998) argue that maladaptive cognitive appraisals and increased attention to threat lead to increased levels of anxiety. This relationship has been shown in experimental studies where states of anxiety were associated with increased attention to threat cues, and an increased likelihood of perceiving the threatening meaning of ambiguous life events (Matthews & Macleod, 1994). This bias towards the perception of threat in anxious individuals has also been identified in developmental studies. For example, Muris, Merckelbach and Damsma (2000) found that socially anxious children (aged 8 to 13) displayed lower thresholds for threat perception and more frequently perceived threat while listening to stories than their nonanxious peers.

These distortions and biases may have several modes of transmission. While some anxious individuals will develop these representations through direct experience of negative situations or stimuli, evidence also suggests that these cognitive styles can stem from parenting factors linked to the transfer of negative information or vicarious modelling from parents to children (Rachman, 1977).

Without treatment, childhood anxiety often persists into adulthood and can lead to a range of negative outcomes, including poorer academic achievement (Lundy, Silva, Kaemingk, Goodwin & Quan, 2010) and an increased risk of developing other health and mental health problems (Costello, Eger & Angold, 2004). However, while childhood anxiety can be problematic for all children and young people, recent research suggests that these difficulties can be especially challenging for individuals with autism spectrum disorders (see White, Oswald, Ollendick & Scahill, 2009 for a review). For these children, the presence of a comorbid anxiety disorder is likely to exacerbate difficulties with social functioning and may lead to a wider range of negative outcomes.

Autism Spectrum Disorders

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition characterized by deficits which lead to significant impairment in social communication and social interaction across multiple contexts as well as restricted, repetitive patterns of behaviour, interests or activities (APA, 2013). According to the DSM-V (APA, 2013) approximately 70% of individuals with ASD suffer from additional psychiatric symptoms leading to the diagnosis of a comorbid mental disorder. Where criteria for a mental disorder are met, individuals with ASD may receive a concurrent diagnosis.

In addition to these core features of ASD researchers have now found evidence to suggest a broad range of functional deficits associated with the disorder. For example, current models of ASD highlight the role of weak central coherence (Booth & Happe, 2010), which refers to an individual's ability to integrate perceptual information into its whole; impaired theory of mind (Baron-Cohen, 1997); and impaired functional language skills (Kjelgaard & Tager-Flusberg, 2010) in individuals with ASD. Theories of executive function also highlight fundamental differences and deficits in cognitive skills including planning, mental flexibility, inhibition, generativity and self-monitoring (for a review see Hill, 2004). Furthermore, individuals with ASD have been found to experience difficulties processing sensory information, such as sensory-over-responsiveness, sensory under-responsiveness and sensory seeking behaviour (Ben-Sasson, Hen, Fluss, Cermak, Engel-Yeger & Gal, 2009). Collectively, these

cognitive deficits are proposed to underpin the diverse behavioural symptoms of the disorder.

Evidence from imaging and other anatomical studies has also highlighted different structural deviation in the brains of individuals with ASD when compared to their peers, indicating underlying differences in neurophysiology . For example, anatomical abnormalities have been reported in a range of brain areas including the cerebellum, the frontal lobes, the parietal lobes, hippocampus and amygdala (Baron-Cohen, 2004). These abnormalities are characterized by differences in neuron density and connectivity and are currently attributed to a range of genetic and nongenetic, or environmental causes (Muhle, Stephanie, Trentacoste & Rapin, 2004).

Anxiety in Children with Autism Spectrum Disorders

The prevalence of anxiety disorders is higher in children and young people with ASD than in their peers. For example, recent studies have reported comorbidity rates varying from 42% to 55% (de Bruin, Ferdinand, Meester, de Nijs &, Verheij, 2007; Simonoff et al., 2008), with the most common forms of anxiety identified as social phobia (30%); Obsessive Compulsive Disorder (17%); social anxiety (17%) and generalised anxiety disorder (15%) (van Steensel, Bögels & Perrin, 2011). However, several reviews have reported prevalence rates between 11% and 84%, depending on the cut-off levels chosen by different researchers (White et al. 2009; Macneil, Lopes & Minnes, 2009; van Steensel et al. 2011). This variation in prevalence rates across different studies in part highlights the heterogeneous nature of this population and may also reflect differences in sample characteristics, including sample sizes, age ranges, symptom severity, measurement issues and diagnosis. Moreover, additional variation is also likely to arise due to difficulties in the assessment of anxiety within ASD.

The assessment of anxiety (or any other emotional symptom) in ASD is complex. For some children with ASD recognising emotions can be a characteristic difficulty of the disorder. Similarly, core difficulties with communication and introspection impact on the ability to recognise, express and report symptoms of anxiety. Consequently, research examining anxiety within this population relies heavily upon reports from other informants, including parents and teachers. However, it is well established that

different informants' ratings of social, emotional behaviour problems in children are frequently discrepant (Achenbach, McMonaughy & Howell, 1987). For example, parental reports of emotional symptoms or psychopathology in their child have been shown to vary as a function of parental depression (Chi & Hinshaw, 2002), parental anxiety (Krain & Kendall, 2000) and stress (Kolko & Kazdin, 1993). While these factors can be problematic for the assessment of anxiety in typically developing children, they are likely to be even more challenging for research involving children with ASD due to the higher levels of parental anxiety, depression and stress in families of children with developmental disabilities including ASD (Ritzema, & Sladeczek, 2011). This is likely to impact on the validity of some of the findings of research within this field.

While "gold standard" assessments exist for the diagnosis of ASD, there is no parallel assessment for anxiety in this population. A recent review by Grondhuis and Aman (2012) explores the issues of assessing anxiety in children with ASD in more detail. They also highlight and comment on the 10 most commonly used assessment tools within this population, of which only three are empirically derived or validated for ASD populations (Autism Comorbidity Interview – Present and Lifetime Version; Autism Spectrum Disorders– Comorbidity for Children; Baby and Infant Scale for Children with Autistic Traits). The authors therefore suggest that research grounded with these instruments will lead to more accurate diagnoses and estimates of prevalence. However, researchers continue to use a variety of different measures which will inevitably impact upon the validity of findings and the ability to generalise between studies.

Nevertheless, while most reports suggest that anxiety is higher in children and young people with ASD, the processes underpinning this association remain unclear. One suggestion is that there may be a common neurobiological impairment in anxiety and ASD. For example, similar structural and functional abnormalities of the amygdala including reduced activation and reduced neural density have been linked to both ASD (Baron-Cohen et al. 2000) and anxiety (Roozendaal, Mc Ewen & Chattarji, 2009). This is of particular interest as these structures are associated with the identification of mental states or emotional information which can be a characteristic

difficulty for individuals with ASD. Similarly, comparable serotonergic abnormalities have been linked to both ASD and anxiety (Stein & Stahl, 2000). However, while these explanations highlight a possible biological link between anxiety and ASD, it is unclear as to the environmental factors that may contribute to this increased risk.

Some researchers have suggested that anxiety may in fact develop secondary to ASD in response to social and environmental demands made more difficult by the functional deficits associated with the disorder. For example, Green and Ben-Sasson (2010) argued that the sensory over-responsivity experienced by individuals with ASD could lead to increased anxiety through greater sensitivity and reactivity to environmental stressors, such as noisy or busy environments. Similarly, Burnette et al. (2005) hypothesised that anxiety may increase as a result of cognitive deficits (i.e deficits in theory of mind and central coherence) making it more difficult for individuals with ASD to interpret and integrate social information from their environment. Furthermore, risk factors for anxiety in TD children are likely to be exacerbated for children with ASD due to increased challenges associated with the disorder for example, parental stress, which has shown to contribute to child anxiety has been shown to be higher in families of children with developmental disabilities such as ASD (Ritzema, & Sladeczek, 2011). Similarly, poorer peer relations can be more common for children with ASD due to their difficulties with social communication, which may increase anxiety due to the protective value of peer relationships (de Matos et al. 2003).

Wood and Gadow (2010) also proposed that ASD symptoms could generate stress and anxiety for individuals when symptom expression is in conflict with social expectations and demands or when these symptoms cause negative reactions from others. They suggest that many individuals with ASD encounter multiple daily stressors, for example demands to conform; difficulty understanding the perspectives of others; sensitivity to sound, touch or light; and isolation or rejection resulting from the social, communicative and behavioural features of ASD. They suggest that these ASD-related stresses could either contribute to increased global negative affect, therefore triggering further negative behaviours such as social avoidance, behavioural problems and emotional distress characteristic of anxiety. Alternatively, through

automatic forms of learning and conditioning specific stimuli can become the focus of fear and anxiety. This process is illustrated in Figure 1.

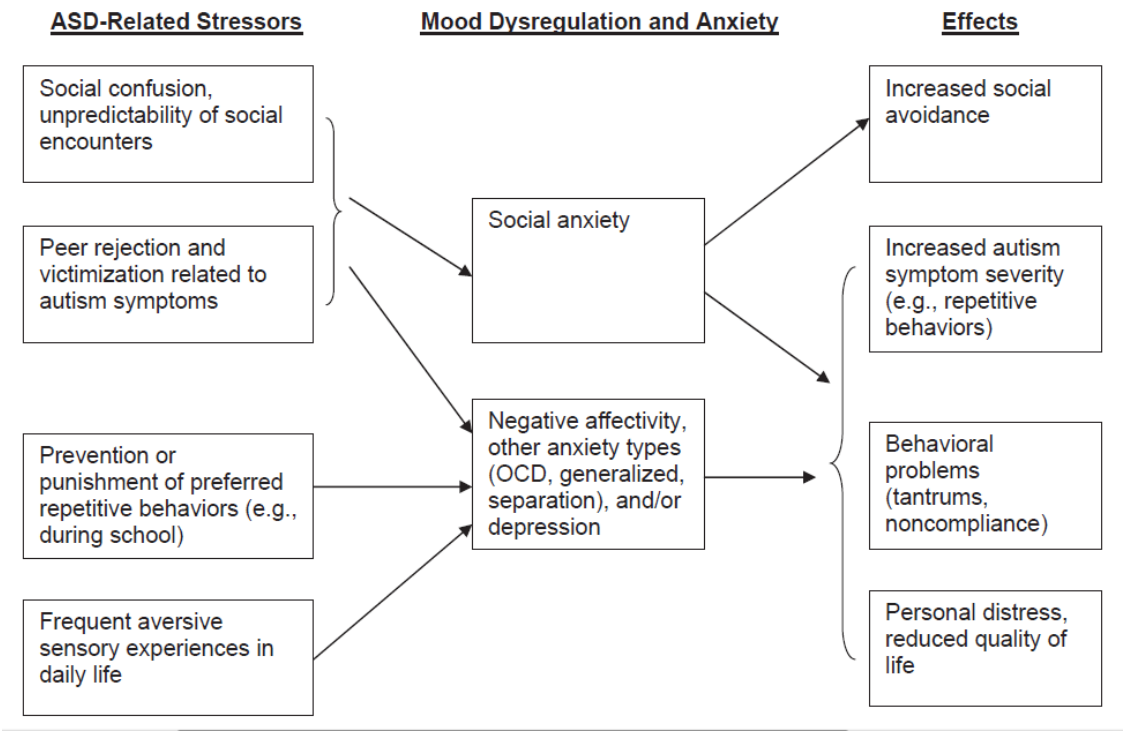


Figure 1: Wood & Gadow's hypothetical model of clinical anxiety in ASD

More recently, researchers have also proposed that an individual's awareness of their own individual difficulties may also contribute to their experience of anxiety. For example, Niditch, Varela, Kemps and Hill, (2012) hypothesised that anxiety in higher-functioning children with ASD could be explained by an increased ability to recognize that their behaviours are not socially acceptable, combined with a lack of capacity to self-regulate or change this behaviour. This could suggest that individuals with ASD who are more able may be more aware of sources of potential threat due to an increased understanding of social expectations and demands, therefore leading to the acquisition of a wider range of threat representations and an increased level of negative affect.

Higher levels of language ability in children with ASD may also increase the number of possible threat representations due to an increased level of understanding. Moreover, as verbal ability increases in children with ASD they become more

susceptible to vicarious learning and negative verbal information, therefore increasing potential sources of anxiety.

Some researchers have therefore suggested that increased intellectual functioning or cognitive ability in young people with ASD can place them at increased risk for the development of anxiety (Niditch et al. 2012). Although this is an emerging area of research, some evidence has been found to indicate that children with high-functioning ASD (HFA) show increased anxiety when compared to those who have low-functioning ASD (LFA) (Bellini, 2004; Mayes, Calhoun, Murray & Zahid, 2011) and that differences exist between ASD subgroups indicating higher levels of generalised anxiety in more able young people with Asperger Syndrome, than in young people with ASD or PDD-NOS (van Steensel et al. 2011).

In summary, these findings highlight that greater cognitive and communicative ability as well as a greater understanding of social relationships may be a risk factor for the development of anxiety in individuals with ASD. However, it remains unclear whether this association is moderated by an increased ability to recognise their own social difficulties, or whether this simply reflects an increased ability to communicate and express feelings of anxiety or negative affect to others.

The aim of this paper is to explore whether greater cognitive skills (IQ level and language ability) represent risk factors for the development of anxiety in children and adolescents with ASD through a systematic review of the research. For the purpose of this review cognitive ability is defined as any measure of intellectual capacity, and is operationalised as either IQ scores, cognitive or developmental quotients (CQ and DQ) or levels of adaptive functioning. Language skills were identified in terms of verbal IQ scores, the presence of functional language use or specific language impairment. This review will therefore help to develop knowledge about risk factors associated with the development of anxiety in ASD and could also be used to develop our understanding of the assessment and treatment of anxiety in this population.

Method

Data Sources

Searches were undertaken in three electronic databases: PsycInfo via EBSCO; Web of Science via Web of Knowledge and Pubmed. After an initial search of these databases 624 papers were identified. Of these papers, 86 full copies were retrieved and assessed for eligibility. A total of 17 papers were included in the final review (PsycInfo via EBSCO, n=12; Web of Science via Web of Knowledge, n=4; Pubmed, n= 3). Details of this process are illustrated in figure 2.

The search terms used in this review were: Anxiety, Autism (or Asperger Syndrome), cognitive (ability), or IQ, communication, language (impairment) and children (or adolescents). These search terms included a list of keywords generated by the author and from those identified in key papers found during the literature search.

Additional articles were obtained from the reference list of key papers and from a manual search of reviews and meta-analyses obtained as part of the literature search.

Participants

Studies were included if participants were under 18 years of age and had no reported comorbid disorders (except anxiety) or disabilities. Studies with older participants were excluded as these groups tended to experience additional difficulties or comorbidities and were therefore not appropriate for the present review. To be included participants had to have a clinical diagnosis of Autism Spectrum Disorder (ASD), Asperger Syndrome or Pervasive developmental disorder not otherwise specified (PDD-NOS). Details of diagnostic criteria used in the particular study were required for inclusion.

Research Design

Studies were eligible for inclusion if they used a quantitative methodology or quasi-experimental design. Studies with or without a control group were both included. Case studies and intervention studies were excluded.

Outcome Variables and Analysis

Only studies with valid, empirically constructed assessment measures and appropriate statistical analysis were included. Studies were excluded if there was no evidence of quantitative analysis. Quantitative analysis could be between groups or within a group.

Publication Requirements

Papers were only included if they were published in peer reviewed journals. Unpublished work such as dissertations, presentations at conferences and review articles were not included.

Data Extraction and Synthesis

Data extracted from papers included participant information (demographics, diagnoses, age, gender) and descriptive information about the study design, specific measures and outcomes.

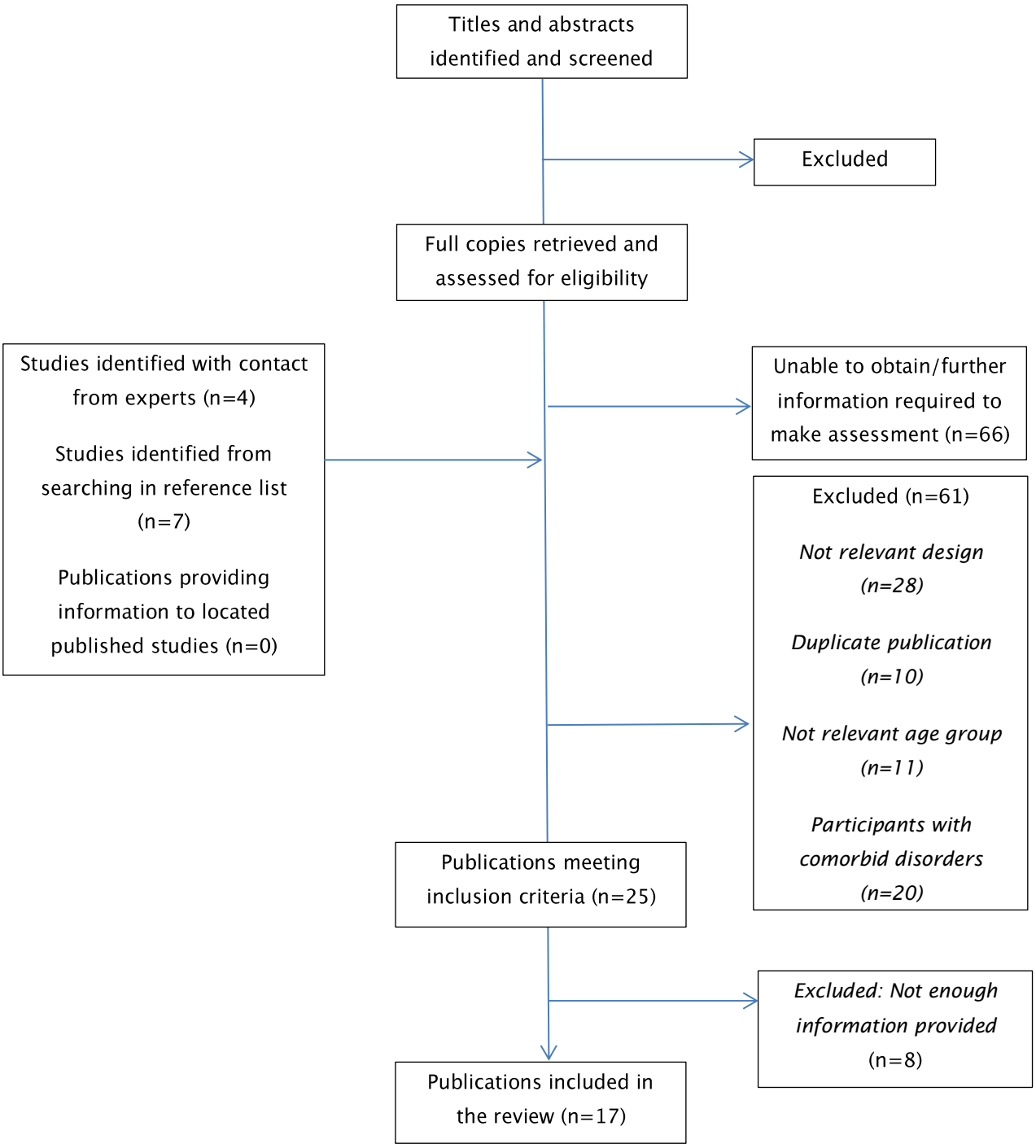


Figure 2: Flow chart of selection process

Results

Sample Characteristics

The studies in this review (see Table 1) included young people aged between 15 months and 18 years who were diagnosed with ASD, Asperger Syndrome or PDD-NOS. Diagnoses were validated in most studies (n=14) using either the Autism Diagnostic Observation Schedule (ADOS; Lord et al. 2000) or the Autism Diagnostic Interview-Revised (ADI-R; Lord, Rutter & LeCouteur, 1994). In others, a more simple screening measure was used and cut-offs applied. For example, the Baby and Infant Screen for Children with autism Traits (BISCUIT; Matson, Wilkins, Sevin, Knight, Boisjoli & Sharp, 2009); Checklist for ASD (Kluth & Shouse, 2009) or the Autism Spectrum Screening Questionnaire (ASSQ; Posserud, Lundervold & Gillberg, 2009). The gender split was predominantly male in all studies (82.4%-88.9%), with the majority of participants being Caucasian (49.1% - 92.5%).

The majority of studies (n=15) used a between groups design comparing parent rated anxiety scores between children and young people with high IQ and low IQ scores. One study used a longitudinal design (Estes et al. 2007) and another featured an experimental design (Lanni, Schupp, Simon & Corbett, 2012). This study was the only study included in the review which collected data on physiological arousal (cortisol). Seven of the studies included in this review featured a control group.

IQ was assessed in most studies (n=10) using standardised IQ measures such as the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999) or the Wechsler Intelligence Scale for Children (WISC IV; Wechsler, 2004). These tools have proven reliability and validity, and are commonly used as a measure of intellectual functioning for children and young people. Researchers have highlighted some limitations for the use of such tools for children with ASD, however Mayes and Calhoun (2007) report that the WISC IV is an improvement on the WISC III for children with ASD and that full scale IQ scores obtained from this measure provide the best single predictor of academic achievement.

The remaining studies used alternative cognitive ability measures for some younger children and participants with intellectual difficulties. For example, the Batelle

Development Inventory (BDI, Newborg, 2004); the Vineland Adaptive Behaviour Scales (VABS; Sparrow, Cicchetti & Balla, 2005) and the Mullen Scales of Early Learning (MSEL; Mullen, 1995). These measures provide a developmental score or level of functioning and categorise children by cognitive quotient (CQ), developmental quotient (DQ) or level of adaptive functioning.

The majority of studies examining language ability (n=6) used measures of verbal IQ as assessed by the WASI (Wechsler, 1999) or WISC (Wechsler, 2004). Again, alternative measures were used for some younger children and for participants with intellectual difficulties, including the BDI, VABS and MSEL.

One study (Lanni et al. 2012) used the Verbal Fluency Test from Delis-Kaplan Executive Function System (Delis, Kaplan & Kramer, 2001). These tests were designed to assess an individual's functional use of language and aspects of expressive and receptive language including semantic and syntactic knowledge, phonology, narrative memory, word fluency. While these measures may not be directly comparable with the verbal IQ scores obtained from the WISC or the WASI, they provide a measure of language development of younger children and children with a range of intellectual abilities.

Most studies (n=15) relied on parent-report for the assessment of anxiety, while one study used self-report (White & Roberson-Nay, 2009) and another used cortisol as a physiological measure of anxiety (Lanni et al. 2012). A range of questionnaire measures were used to assess anxiety via parent report including the Revised Child Anxiety and Depression Scale (RCADS; Chorpita, Yim, Moffitt, Umemoto & Francis, 2000); Child and Adolescent Symptom Inventory (CASI; Gadow & Sprafkin, 2012); Kiddie Schedule for Affective Disorders (K-SADS; Endicott & Spitzer, 1978); Screen for Child Anxiety Related Emotional Disorders (SCARED; Birmaher, Khetarpal, Cully, Brent & McKenzie, 1995); Pediatric Behaviour Scale (PBS; Marshall & Wilkinson, 2006); and the Child Behaviour Checklist (CBCL; Achenbach & Rescorla, 2001).

Only three studies (Davis III et al, 2011; Davis III et al, 2012; Rieske et al, 2013) used measures designed specifically for use with children with ASD. These studies

featured either the Autism Spectrum Disorders- Comorbidity for Children (ASD-CC), the Child and Adolescent Symptom Inventory-PDD, or the Baby and Infant Screen for Children with aUtIsm Traits (BISCUIT; Matson et al. 2009);

One further study devised their own measures of anxiety using criteria informed by the DSM IV (Davis III et al. 2011). Further information was not provided as to the content of this checklist; however it was reported to have a high degree of reliability when compared to other measures, including the ASD-CC.

Gender differences and age effects

Because of the nature of ASD the participants included in these studies were predominantly male. It was therefore difficult for the authors to comment on gender differences. However, one study found that there were no differences in anxiety severity between boys and girls (Sukhodolsky et al. 2007). This is in contrast to gender differences in the typically developing population where girls typically report more anxiety symptoms. Nevertheless this finding may need to be treated with caution due to the disproportionately male sample (n = 145; 84% male).

Although the majority of studies did not compare age differences between participants, one study found that age of participant moderated parental reports of anxiety (Mayes et al. 2011) whereby more anxiety symptoms (as assessed by the PBS) were reported with increasing age (r= .32, p<.0001). This finding is consistent with reported prevalence rates within typically developing populations (Green et al. 2005). However, the majority of studies which explicitly comment on age differences found no evidence to suggest that age impacted upon anxiety scores (Strang et al. 2012; Gotham et al. 2013; Sukhodolsky et al. 2007).

The relationship between cognitive ability and anxiety

Several studies in this review provide evidence to suggest that there was a positive association between IQ scores and anxiety in children with ASD. For example, in a study with 445 participants aged 4-17 (recruited from a randomised controlled trial as part of a larger project), Hallett et al. (2013) asked parents to rate their child's anxiety using the CASI and CASI-PDD. These measures are designed to assess anxiety

symptoms in children aged 4-18, including generalised anxiety, post-traumatic stress disorder, somatization, social phobia, obsessive compulsive disorder, simple phobia and panic disorder. The latter measure has been validated for use with ASD populations. Although Hallett et al. did not provide information as to the range of IQ scores of participants, they found evidence to suggest that children with an IQ score of 70 or above (n= 192) were rated as significantly more anxious (based on total anxiety scores) than those with IQ scores below 70 (n= 200) and that nonverbal children with IQ scores below 70 (n= 69) had even lower anxiety scores. These findings indicate that anxiety scores were positively associated with IQ and that verbal (compared with nonverbal) children experienced more anxiety.

Similar findings have been found in other studies. For example, Mayes et al (2011) asked the parents of 627 children and adolescents aged 1-17 to complete measures of anxiety, this time using the Problematic Behaviour Scales (PBS; Marshall & Wilkinson, 2006). The PBS is a 165 item subscale that yields scores on several subscales including a total anxiety score. Consistent with Hallett et al (2013), the results showed that anxiety in children with ASD was positively associated with IQ (IQ range was 16 to 146; M= 88, SD = 27). Children with HFA (IQ>80, n= 404) were rated by their parents as significantly more anxious than children with LFA (IQ<80, n= 223) with a small effect size (4.1%; d=0.4)

Mayes et al. (2011) also found evidence to suggest that verbal IQ was more strongly associated with anxiety (r=.29, p<.0001) than nonverbal IQ (r=.12, p=.037). This suggests that anxiety may be more closely linked to verbal ability as opposed to a more global cognitive ability. The best combined predictors of anxiety in this study were increasing autism severity, verbal IQ and increasing age explaining 25% and 23% of the variance. However, these differences between verbal and nonverbal children (Hallett et al, 2013; Mayes et al, 2011) could also be explained by a reporting bias as verbal children may simply be more able to express their feelings of anxiety to their parents.

This association between anxiety and cognitive ability has also been found in younger children. For example, in a large study with 2336 children aged 17-36 months, Rieske, Matson and Davis III (2013) found evidence to suggest that both

cognitive and adaptive Developmental Quotients (as assessed by BDI-2; Newborg, 2004) predicted anxiety scores (based on behavioural indicators of anxiety) as rated by parents using the BISCUIT (Matson et al. 2009).

Some evidence has also been found to suggest that intellectual functioning at an early age can predict patterns of emotional and behavioural symptoms in later life in children with ASD. For example, in a longitudinal study by Estes et al. (2007), IQ at 6 years (n= 74) predicted parental report anxiety symptoms at age 9. These findings indicated that children in the higher IQ group (>70) at age 6 had significantly higher scores for anxious/depressed in the CBCL by age 9, when compared to the lower IQ group (<70). When analysing differences between groups Estes et al. also found that lower cognitive functioning in children at age 6 was associated with higher levels of hyperactivity, irritability and stereotyped behaviour at age 9. While replication and causative designs are needed, this finding may provide some evidence to suggest that lower functioning children with ASD are more likely to develop externalising symptoms, whereas higher functioning children may demonstrate more problematic internalising behaviour. This idea is consistent with existing literature indicating that externalising behaviours (such as aggression) are associated with learning and communication difficulties in childhood and adolescence (Clark, Prior & Kinsella, 2002).

However, not all studies found a relationship between anxiety and IQ and where positive associations were identified some found small effect sizes. For example, in a study of 1429 participants aged 5 to 18 years, Gotham et al. (2013) found that verbal IQ predicted parent report (CBCL) anxiety scores, but the reported effect sizes of verbal IQ on these anxiety scores were small (r= 0.17, r^2= 0.03). Similarly, effect sizes for the relationship between HFA and anxiety were also small in the Mayes et al. study (d= 0.4).

Two studies found no significant relationships between anxiety and IQ (Strang et al. 2012; Eussen et al. 2013). In Strang et al's study (n=95, IQ range =71-144, M=105, SD= 17) no significant relationships were observed between cognitive ability (as assessed by the WISC IV; n=54 or the WASI; n=41) and emotional symptoms (including parent reported CBCL anxiety). Independent samples t-tests comparing

participants with elevated anxiety symptoms (60.4%) with participants with non-elevated anxiety symptoms (39.6%) also revealed no differences between full scale IQ scores, verbal ability or non-verbal ability.

Similarly, In Eussen et al's (2013) study (n=134, IQ range= 48-124; M=91.84, SD=17.44) no significant relationships were observed between IQ and anxiety. However, further analysis revealed that higher mean levels of anxiety were identified in the group with IQ ranging from 70-87 (compared to those with IQ scores lower than 70 or higher than 87). This group difference did not reach significance.

Although these findings contrasts the majority of studies included in this review, it is possible that the IQ range of participants in these studies was not sufficient to detect any effects. While most of the other studies discussed featured participants with a broad range of intellectual abilities, these studies featured participants with higher mean IQ scores, most of which falling within or above the normal range. It is therefore possible that any associations were hidden or do not hold true for children with IQ scores within this range or are most evident within a specific IQ range.

Only one study identified a negative relationship between anxiety and IQ scores, where the results indicated that anxiety increased as IQ decreased (White & Roberson-Nay, 2009). Again, this study included a high functioning participant group (mean IQ 92.24, SD=14.41) and is one of the only studies to include self-reported anxiety (assessed using the Multidimensional Anxiety Scale for Children; MASC) as opposed to parent rated. Moreover, they found little agreement between parent and self-reported anxiety with parent report being more closely tied to social impairment and limited interaction. In this study, the children in the lower IQ group (IQ<92) had a mean total anxiety T score of 64.44 (±16.69), compared to 49.88 ± 7.20 for the higher IQ group (IQ>92). This suggests that children with lower IQ scores reported more anxiety than those with higher IQ scores. However, this study featured a relatively small sample size (n=20) therefore findings may need to be treated with caution. Similarly, this study was the only one to feature self-report as opposed to parent-report, therefore it may be difficult to accurately compare findings with other studies.

A further way of exploring the role of cognitive ability in children with ASD is by comparing anxiety symptoms in different subgroups of ASD. As previously mentioned anxiety has also been found to vary across subgroups of ASD with higher rates of anxiety reported in children with Asperger Syndrome than children with ASD or PDD-NOS (van Steensel et al. 2011). However, this association may be explained as a function of cognitive ability. For example, Gadow, Devincent and Pomeroy (2005), compared parent and teacher-rated anxiety scores (generalised anxiety; separation anxiety; specific phobia; obsessions; and compulsions) using the Child Symptom Inventory-4 (CSI-4) in a sample of children with ASD (n=103), Asperger Syndrome (n=80) and PDD-NOS (n=118). The results showed that children with Asperger Syndrome had more severe GAD symptoms than children with ASD and PDD-NOS (as reported by both groups), indicating that this form of anxiety was higher in children with Asperger Syndrome than children with ASD or PDD-NOS. However, when grouping participants by IQ, they found significant differences between groups suggesting that GAD scores were higher in children in the higher IQ group (IQ>70) regardless of ASD diagnosis. In other words, differences between subgroups could be explained by group differences in IQ scores.

Similarly, in studies by Niditch et al. (2012) (n=231) and Hallett et al (2013) differences were also found between ASD subgroups (autistic disorder, Asperger Syndrome and PDD-NOS), indicating that children with Asperger Syndrome were more likely to meet criteria for anxiety disorders than children with a diagnosis of ASD or PDD-NOS. However, in both studies, further analyses indicated that variability in IQ scores between groups explained the variation in anxiety scores rather than the membership of the subgroups themselves. This provides further support for the proposition that anxiety is associated with cognitive ability.

The relationship between intelligence and anxiety sub-groups

While the majority of studies have found positive associations between cognitive ability and anxiety scores, there still remains some inconsistency in the research with some studies finding no relationships. This could suggest that only specific subgroups

of anxiety may be related to intelligence or cognitive ability; that patterns emerge with age or that differences emerge as a function of anxiety type. Some researchers have explored this relationship by examining different domains within anxiety and found evidence to suggest different patterns of anxiety and variability exist within ASD such that different domains interact in different ways with cognitive ability factors.

For example, Hallett et al. (2013) found that the only significant positive association between parent-rated anxiety (using RCADS) and IQ in ASD participants was for social anxiety. Conversely, a negative association was observed between IQ and separation anxiety, indicating that children with higher IQ scores were rated lower in separation anxiety scores.

Similarly, in a study with 172 participants aged 5-17 years, Sukhodolsky et al. (2007) also found evidence to indicate that different anxiety domains may be affected by IQ scores in different ways. They found that children with higher IQ scores were more likely to meet criteria for GAD, somatization and separation anxiety disorder (as rated by ABC and CASI) when compared to children with IQ scores below 70. However, no such relationships were found between IQ scores and social phobia, panic disorder or simple phobia.

In another study, Witwer and LeCavalier (2010) found that children without intellectual disability (IQ>70) were more likely to meet criteria for GAD (as assessed by the Children's Interview for Psychiaric Symptoms- Parent Version; P-ChIPS) than their peers with intellectual disabilities (IQ<70) (IQ range of 42-150; M= 68.4, SD= 23.3). However, IQ itself was only positively associated with specific symptoms of GAD ("worry more than others", "hard to relax when worried" and "trouble letting go of worries"). These findings suggest that children with higher IQ scores are more likely to worry than those with lower scores.

Conversely, some research also indicates that forms of anxiety are high across levels of cognitive ability. For example, although Sukhodolsky et al (2007) found evidence to suggest that higher IQ scores were associated with higher levels of general anxiety, symptoms linked to simple phobias and social anxiety were equally elevated in both high and low IQ groups.

One interpretation of the above findings could be that certain forms of anxiety such as separation anxiety, social anxiety and generalised anxiety disorder may increase with IQ due to an increased awareness of social expectations and demands, combined with behavioural conflict resulting from the associated difficulties or deficits of ASD. Alternatively, other forms of anxiety such as specific fears and phobias may not vary as a function of IQ scores. It seems possible that these forms of anxiety may be more directly linked to negative and aversive experiences or may be closely tied to the core ASD symptoms and may therefore not be associated with IQ.

The relationship between language ability and anxiety in ASD

Several studies have suggested that verbal IQ is a better predictor of anxiety than performance IQ, indicating that children with higher verbal IQ scores tended to exhibit higher levels of anxiety (Mayes et al, 2011; Estes et al, 2007; Gotham et al, 2013; Hallett et al, 2013). Accordingly, nonverbal children with ASD experience less anxiety than their verbal peers as assessed by total anxiety scores from the CASI (Hallett et al. 2013; Sukhodolsky et al 2007). This therefore suggests that increased verbal ability or verbal IQ places children diagnosed with ASD at increased risk for the development of anxiety.

Studies that directly compare children with ASD with TD children also highlight these different relationships between language ability and anxiety in these groups. For example, in a study with 99 children aged 2-14 (M=7.46, SD= 2.79), Davis III et al. (2011) compared level of anxiety (as reported by parents) with the degree of communication deficits experienced (assessed by Autism Spectrum Disorders-Diagnostic for Children; ASD-DC). Participants were then grouped into one of three categories, ASD (n=33), PDD-NOS (n=33) and TD (n=33) and group differences were explored. Using hierarchical regression analyses a three step interaction was modelled which indicated that the degree of communication deficit was found to moderate the relationship between diagnostic group and level of anxiety. This final model indicated that children with ASD experienced less anxiety as communication deficits increased, while children with PDD-NOS and TD children experienced more anxiety as communication deficits increased.

In another study, Davis III et al (2012) also observed this relationship in infants and toddlers aged 15 to 36 months (M=26.1, SD=4.9). Here, anxiety increased as communication skills increased for children with ASD or PDD-NOS, but for children in the typically developing group the presence of greater communication skills did not have a significant impact on the observed level of total anxiety symptoms.

While the other studies featured in this review have explored the association between measures of trait anxiety and cognitive or language ability, one study instead assessed state anxiety using salivary cortisol as a physiological measure (Lanni et al.2012). Interestingly, this study indicated that verbal ability was not associated with state anxiety in children with ASD. In this study, Lanni et al. used an experimental design known as the Trier Social Stress Test (TSST; Kirschbaum, Pirke & Hellhammer, 1993) which is designed to induce anxiety in participants and consists of an anticipation period and a test period which is designed to induce social stress. In this study, Lanni et al compared children (aged between 8 and 12) with ASD to TD children on several tasks of verbal ability including narrative memory, phonemic fluency, category fluency and category switching fluency and examined their physiological responses to the TSST.

While the children with ASD performed slower than the TD group on tasks of verbal switching and story recall than TD children there were no observed relationships between physiological arousal following the TSST and any of the cognitive tests. They concluded that verbal ability in children with ASD did not predict physiological anxiety responses (cortisol).

These findings therefore suggest that the level of physiological arousal associated with anxiety may not necessarily vary in relation to verbal ability in children with ASD and that the differences observed in other studies may simply reflect an increased ability to express their feelings of anxiety or negative affect to others. It therefore seems possible that the differences in anxiety observed across individuals with different levels of verbal ability may be explained by individual differences in the ability to express feelings of anxiety or negative affect to others. For instance, while several studies have shown that nonverbal children with ASD are less anxious than verbal children (Hallett et al, 2013; Sukhodolsky et al, 2007), these children instead

demonstrated higher levels of externalising behaviour, for example aggression (Niditch et al. 2012).

Further evidence for this hypothesis comes from Estes et al's (2007) study which explored the relationship between intellectual functioning (including verbal ability) and patterns of associated symptoms in school age children with ASD. In this study, 74 participants were grouped as either higher verbal IQ (>70) or lower verbal IQ (<70). As with previous studies the higher verbal IQ group were reported to have higher scores in anxiety (as assessed by the anxious/depressed scale of the CBCL) than those with lower verbal IQ. However, the children with lower verbal IQ were reported to have more thought problems, including strange ideas and behaviours (assessed by the CBCL), higher levels of hyperactivity (assessed by the ABC and Conners rating scale) and more stereotyped behaviours (assessed by the ABC).

This research could suggest that children with ASD demonstrate different responses to stressful events or threatening situations as a function of communicative skill. While children with higher verbal ability may be able to express their underlying negative affect through behaviour consistent with anxiety symptoms, children with lower verbal ability may be more likely to respond to similar challenges with increased externalising behaviours.

In summary, cognitive ability may play an important role in the presentation of anxiety, for example through an increased understanding of the difficulties and deficits experienced by the individual combined with an increased sensitivity to additional sources of stress including vicarious learning and negative verbal information. This could potentially lead to a greater number of threat representations or increased threat bias through an increased awareness to social expectations and demands. However, this anxiety may be expressed in different ways for children with different levels of communication skill. More specifically, while verbally able children are able to express their feelings of anxiety in a manner similar to TD children and in line with current definitions and assessments, it seems possible that children with limited communication skills may respond to similar stressors through means of challenging or externalising behaviour.

Quality Assessment

All of the above studies included in this review reported information regarding the study hypotheses/aims, outcomes, participant characteristics, measures, principal findings variability and confounding variables. Adequate information was also provided where appropriate, for attrition and the loss of participants at follow up. However, not all studies provided adequate information regarding participant selection. While all but two studies (11.7%) (Lanni et al. 2012; Witwer & Cavalier, 2010) reported their recruitment strategy, only four studies (23.5%) described the sampling technique in sufficient detail. Of these studies, two utilised randomised designs (11.7%) (Hallett et al. 2013; Sukhodolsky et al. 2007); four (23.5%) recruited participants through consecutive referrals to clinics or intervention programmes (Eussen et al. 2013; Gadow et al. 2005; Rieske et al. 2012Strang et al. 2012) and two (11.7%) used archival data (Nidditch et al, 2012; Simonoff et al. 2008). Two further studies (11.7%) featured participants recruited as part of other longitudinal studies (Hallett et al. 2013: Estes et al. 2007).

External validity is weak for the majority of these studies as samples were obtained from clinics and may therefore not be representative of the wider population of individuals with ASD not seeking specific help for anxious symptoms. Although sample sizes were generally large, not all studies gave details of effect sizes.

All studies used empirically validated and constructed measures which have been tested for internal reliability and consistency within TD populations. However, only four of the above studies used measures of assessing anxiety that were validated for use with ASD participants (Davis III et al 2011; Davis III et al 2012; Hallett et al. 2013; Rieske et al. 2013). These studies all identified positive associations between anxiety and either IQ scores, developmental quotients or communicative skill.

Only seven (41.2%) of the studies featured in this review included a control group. This makes it more difficult to ascertain whether the relationships between anxiety and IQ are unique to children with ASD or whether they are representative of the general population. Furthermore there was insufficient information provided in four studies

(23.5%) regarding IQ ranges. This has implications on the generalisation of findings between studies.

The lack of self-reported measures of anxiety in the above studies could also be of concern. This could therefore mean that measurements reflect expressed anxiety as opposed to actual experienced anxiety or negative affect. While this is understandable due to the associated difficulties of assessing emotional states in individuals with ASD, this will still inevitably impact upon the validity of findings. Further research using validated measures for ASD or methods of multi-modal assessment would help to validate existing findings. Only one study examined the physiological experience of anxiety (Lanni et al. 2012). It would be useful if further research also included physiological measures in addition to self-report and parent/teacher report measures in order to triangulate findings across respondents.

Discussion

Rates of anxiety are higher in children and young people with ASD compared to their TD peers (White et al. 2009; Macneil et al. 2009; van Steensel et al. 2011). However, the precise factors that contribute to the development of anxiety in children and adolescents with ASD and the underlying pathways for this association remain unclear. This review sought to explore these underlying factors more carefully by examining the role of cognitive and language ability as risk factors for the development of in anxiety for children and young people with ASD.

The majority of studies included in this review provided evidence to suggest that parent-rated anxiety was positively associated with cognitive ability in children and young people with ASD. In other words, as participants' IQ scores or developmental quotients increased, so did their anxiety scores. For example, children with an IQ score of 70 or above were rated as significantly more anxious than those with IQ scores below 70 (Hallett et al. 2013). Children with HFA were also rated as significantly more anxious than children with LFA (Mayes et al. 2011). These findings were consistent across several studies using a range of measures (Estes et al. 2007; Niditch et al. 2012; Rieske et al. 2013).

One explanation for these findings is that anxiety increases as a function of understanding of social and environmental cues, whereby anxiety is higher in more able children who are more aware of their individual difficulties and the challenges they experience within their environment. These children may develop more representations of social or situational threats due to a greater understanding of and difficulty managing their individual difficulties. Thus, while all children with ASD are likely to experience multiple daily stressors associated with the functional deficits of the disorder, some may be less likely to experience negative affect or worry about these experiences if they have difficulty understanding social conventions or expectations. Similarly, children with higher IQ scores or levels of intellectual functioning may be more susceptible to additional sources of stress and anxiety acquired through vicarious learning experiences or by negative verbal information.

Conversely, two studies did not find this relationship between cognitive ability and anxiety (Strang et al 2012; Eussen et al. 2013) and one study identified a negative association between IQ scores and anxiety levels (White & Roberson-Nay, 2009). These discrepancies in the pattern of findings may be explained through variations in sample characteristics including age ranges and symptom severity. White and Roberson-Nay's (2009) study also included a much smaller sample size (n=20) and was the only study to use a self-report measure which makes it difficult to compare with the other studies featured in this review which predominantly used parent reports of anxiety.

The evidence also suggests that associations between higher IQ scores and higher rates of anxiety may not hold true for children with ASD who are within the normal range for intellectual functioning. The majority of studies included in this review featured children with a broad range of intellectual ability and where reported, mean IQ scores were often below the typical level. However, Strang et al. (2012) and Eussen et al (2013) featured a much smaller range of ability with most participants scoring within the normal range for intellectual functioning. This could suggest that IQ is only associated with anxiety for children below a certain cut-off point. Moreover, in the Eussen et al (2013) study, the highest mean level of anxiety was identified in the group with IQ scores ranging from 70-87 compared to those with IQ scores below 70

or above 87. It could therefore mean that the association between IQ and anxiety only holds true for children with IQ scores below average levels. Further research is required using samples of children within the normal range for intellectual functioning (IQ of 85-115) to explore this hypothesis further.

Variation was found between different domains of anxiety across developmental levels. For example, Sukhodolsky et al (2007) found positive associations between generalised anxiety disorder, somatization and separation anxiety disorder and IQ, but no such relationships were found between IQ scores and social phobia, panic disorder or simple phobia. Additionally, some types of anxiety (social phobia, panic disorder or simple phobia) were high in children with ASD regardless of intellectual ability. These findings highlight the complex association between anxiety and intellectual functioning, with different patterns and potential developmental pathways for different types of anxiety.

One explanation for these findings is that some types of anxiety, such as social phobia, panic disorder or simple phobia may be associated with the direct experience of negative or aversive stimuli while other forms of anxiety such as social anxiety and separation anxiety may require a higher level of understanding and reflection and require greater cognitive capacity. Although these types of anxiety may also develop through direct experience; it is the individual's awareness of these difficulties and understanding of the social and situational demands which lead to the development of these forms of anxiety. In other words it is not necessarily the experience itself that accounts for anxiety, but how that individual thinks about it.

This idea parallels the distinction between fears and worries that has been made within the TD population. According to this definition of anxiety, fear and worry are two distinct anxiety phenomena (Muris, Merckelbach & Luitjen, 2002). While fear occurs when an individual is confronted by a situation which they perceive as threatening or dangerous, worry takes place in the absence of this stressor and is primarily concerned with how the individual thinks about these threatening scenarios.

It has been suggested that the developmental patterns of fears and worries are mediated by children's cognitive capacities and that the development of fears and

phobias may precede worries (Muris, Merckelbach & Luitjen, 2002). It therefore seems likely that for some less able children with ASD, anxiety may be linked to more concrete, straightforward threats, for example aversive sensory stimuli such as a busy and noisy environment. However, as intellectual ability increases, these children may become more able to recognise and understand their specific difficulties and to infer physical cause-effect relationships between events therefore allowing them to predict potentially negative outcomes. This leads to an increase their capacity to worry. Thus, some types of anxiety, for example specific phobias, require less cognitive capacity and therefore may be common irrespective of ability while more complex worries may develop only as intellectual functioning or ability increases.

It is also important to consider the role of verbal ability in the presentation of anxiety for children and young people with ASD. For example, several studies have shown that verbal IQ is a better predictor of anxiety than performance IQ or full scale IQ scores (Mayes et al, 2011; Estes et al, 2007; Gotham et al, 2013; Hallett et al, 2013). Therefore, language ability is likely to play a role in the manifestation of anxiety for these children. Interestingly, in the TD population, anxiety has been shown to increase with language impairment (Conti-Ramsden & Botting, 2008), however the opposite relationship has been observed in participants with ASD. For example, Davis III et al. (2011) identified different patterns of association between language ability and anxiety in school aged children with ASD, PDD-NOS and controls. For children with ASD anxiety decreased as communication deficits increased, while for children with PDD-NOS and TD children anxiety increased as communication deficits increased.

These findings raise the question as to why increased language ability places children with ASD at increased risk of developing anxiety, while the converse is true for their peers? Davis III et al (2011) provide two straightforward interpretations- 1. Severe communication deficits in children with ASD can lead to decreased anxiety as they reflect a larger deficit across a range of functioning and a decreased ability to be anxious, or 2. Increased communication deficits in children with ASD impair their ability to express or demonstrate symptoms of anxiety as they are currently defined or assessed. However, these explanations may be overly simplistic due to the fact that

developmental factors are likely to influence changes that affect both communication skills and anxiety over a lifetime.

Another interpretation is that for TD children, the presence of an SLI or communication deficit may add specific challenges and contribute to that individual's difficulty navigating their environment, therefore increasing anxiety. In contrast, for children with ASD, language impairment may limit their understanding of social situations, expectations and interactions, thus reducing their awareness of the challenges that they face. This could manifest itself in lower levels of anxiety.

As with cognitive ability, the positive association between language ability and anxiety in ASD could in part be explained by an increased level of understanding and an increased sensitivity to negative verbal information of vicarious learning. Similarly, children with increased language skills may be more able to develop mental representations of stressful situations meaning that they are more likely to worry even in the absence of a direct stressor. However it is also possible that these differences simply indicate an increased ability to express anxiety in children with better language skills.

The majority of studies included in this review relied solely on parental report to assess anxiety symptoms. It is therefore possible that these studies are not providing an accurate assessment of the experience of anxiety for children and young people with ASD. In fact, it has been suggested that these measures may only be reflecting the individual's ability to express feelings of anxiety and not the underlying anxiety itself (Tsai, 1996).

A study which measured physiological arousal in children with ASD provided some support for this proposition. In Lanni et al's (2012) study, verbal ability in children with ASD did not predict salivary cortisol or anxiety responses. In other words, children's arousal to a stressful social situation did not differ as a function of language skill. This finding suggests that children with ASD may all experience similar levels of arousal to stressors regardless of verbal ability. This may explain differences observed in the other studies through a decreased ability to express these feeling to others. Accordingly, Niditch et al's (2012) found that while less able

children were rated as less anxious, they instead presented higher levels of externalising behaviour which may reflect an externalising expression of anxiety. Similarly, Estes et al (2007) also found that children with higher IQ scores were more likely to demonstrate internalising behaviours in response to stressors whereas children with lower IQ scores demonstrated greater levels of externalising behaviours. This could therefore suggest that more verbal children respond to negative affect with behavioural symptoms which are recognisable as anxiety, whereas children with poorer verbal skills may communicate this same discontent through challenging or externalising behaviour.

In summary, research has shown that both cognitive ability and language skill are likely to play an important role in both the development and expression of anxiety symptoms for children with ASD. However, although both IQ and language skills have been shown to be associated with anxiety it seems likely that they mediate this relationship in very different ways. While some children with ASD may develop certain types of anxiety (fears and phobias) in response to direct experience with aversive or challenging situations or through specific behavioural conflict, other more complex forms of anxiety (social anxiety and general worries) may develop with increased cognitive ability due to a greater understanding or recognition of environmental and social stressors as well as an increased sensitivity to vicarious learning experiences and negative verbal information. This may explain findings of increased anxiety in children who are more cognitively able. However, the expression of this anxiety may be mediated by communicative skill or language ability, whereby more verbally able children are more effective at communicating their feelings of anxiety to others, while less verbally able children may express anxiety or negative affect through the manifestation of higher rates of challenging or externalising behaviour.

Limitations and Future Research

One significant limitation in the current research is the reliance on parental report as the only source of assessment of anxiety in participants. Furthermore, the majority of measures used to assess anxiety in these studies have not been validated for use with individuals with ASD, nor are there suitable or reliable norms for these

populations. Only four studies used measures which have been validated for use with children with ASD (Rieske et al. 2013; Davis III et al. 2012; Davis III et al. 2013; Hallett et al. 2013).

A further limitation of current research is associated with a lack of consistency in measures for the assessment of cognitive and language ability across studies and the range of IQ levels of participants included within individual studies. Given that positive associations between IQ scores and anxiety may not be found in children within the average range (Strang et al. 2012; Eussen et al. 2013) additional research is required to clarify how cognitive ability is associated with anxiety in ASD.

In addition to these limitations, external validity may also be weak for some studies due to a large number of participants being recruited from clinical settings. This means that findings might not hold true for other populations.

The differences observed in associations between IQ and different subgroups of anxiety also indicate that different pathways may be involved in the development and manifestation of anxiety and its symptoms for different ability levels within ASD. This has implications on our understanding of anxiety in ASD and is required to help identify children who are at risk for developing a wider range of disorders.

The impact of language skills on the ability to express anxiety also has useful implications in terms of our understanding of the assessment of anxiety. It may also help us better understand the cause of some externalising behaviours in children with ASD and poorer communication skills. However, this finding also raises questions about the appropriateness of some existing measures of anxiety for use in this population and may even suggest that a different conceptualisation of anxiety and negative affect may be appropriate for children and young people with ASD. Further research would therefore be useful to explore how anxiety might be more objectively measured in this population and how these measures correlate with existing self-report or parental-report measures to increase the validity of research in this area. This form of triangulation would help provide a much clearer understanding of how anxiety is experienced by individuals with ASD.

Table 1: Review of studies and results

Authors	Journal	Design	Participants	Measures	Sampling Technique	Results
Davis III, T.E., Moree, B.N., Dempsey, T., Hess, J.A., Jenkins, W.S., Fodstad, J.C. & Matson, J.L.	Behavior Therapy	Between groups design (with control)	735 children aged 15 to 36 months (M=26.1, SD= 4.9)	*BISCUIT* *Batelle Developmental Inventory-Second Edition (BDI-2):*	Recruited from state funded early intervention programme. Further details not given.	For infants in the AD/PSS-NOS groups, as communication skills increased so did their scores on the total anxiety index. However, for infants in the atypically developing group, the presence of more communication skills did not have a sig. impact on the observed level of total anxiety symptoms.
Davis III, T.E., Moree, B.N., Dempsey, T., Reuther, E.T., Fodstad, J.C., Hess, J.A., Jenkins, W.S. & Matson.	Research in Autism Spectrum Disorders	Between groups design (with control)	99 children aged 2-14 (M=7.46, SD= 2.79)	*Autism Spectrum Disorders- Diagnostic for Children (ASD-DC)* *Autism Spectrum Disorders- Comorbidity for Children (ASD-CC)* *Composite symptom checklist developed from DSM-IV and the International*	Recruited as part of another study. Further details not given.	The final model accounted for a significant portion of variance in anxiety (R^2=.390; F(4,94) = 15.03, p<.001) meaning that the degree of communication deficits was found to moderate the relationship between diagnostic group, and level of anxiety experienced.

				Classification of Diseases (ICD X)		The ASD and PDD-NOS groups interacted with communication deficits such that children with autistic disorder experienced less anxiety as communication deficits increased, while children with PDD-NOS and TD controls experienced more anxiety as communication deficits increased.
Estes, A.M., Dawson, G., Sterling, L., & Munson, J.	American Journal on Mental retardation	Parent rated questionnaire, between groups design (no control)	74 children recruited as part of a National institute for Child Health and Human Development (NICHD) longitudinal study (M=73 months, SD=	*Autism diagnostic interview Revised (ADI-R)* *Autism diagnostic observation schedule (ADOS)* *Child Behaviour Checklist (CBCL)* *Conners Parent Rating Scale* *Aberrant Behaviour Checklist (ABC):*	Participants recruited from clinical population as part of longitudinal study undertaken by the National Institute for Child Health and Human Development (NICHD)	Children in the higher verbal IQ group at age 6 had sig. higher scores for anxious/depressed in the CBCL by age 9 as compared to lower verbal IQ group (M=58.2 SD=6.72 Vs M=53.12 SD= 4.26)

			2.8)			
Eussen, M.L., Van Gool, A.R., Verheij, F., Verhulst, F.C. & Greaves-Lord, K.	Autism	Parent rated questionnaire, between groups design (no control)	134 school aged children	*Autism diagnostic observation schedule (ADOS)* *Wechsler Intelligence Scale for Children (WISC IV)* *Child Behaviour Checklist (CBCL)* *Children's Communication Checklist (CCC)*	Participants recruited from an outpatient's department of Child and Adolescent Psychiatry	intelligence was not related to anxiety levels in this sample
Gadow, K.D., Devincent C.J., Pomeroy J. & Azizian A.	Autism	Parent rated questionnaire, between groups design (with control)	301 particpants aged 6-12 with PDD and 191 controls	*Autism diagnostic interview Revised (ADI-R)* *Child Symptom Inventory-4 (CSI-4*	PDD participants were recruited from clinical population via postal invitation. Control participants were systematically selected from four mainstream settings within the same geographical area.	children with higher IQs (≥70) were rated as having greater psychiatric symptom severity
Gotham, K., Bishop, S., Hus, V., Huerta, M.,	Autism Research	Parent rated questionnaire, between groups design	1429 children aged 5 years 8 months to 18 years 0 months	*Autism diagnostic interview Revised (ADI-R)* *Autism diagnostic*	Data collected from existing database as part of a genetic consortium study.	Verbal IQ was significantly higher in the highest anxiety x highest IS group (M=89.2, SD=26) than it was for both

Lund, S., Buja, A., Krieger, A. & Lord, C.		(no control)	(M=10:2, SD= 3:1)	*observation schedule (ADOS)* *Vineland Adaptive Behavior Scales- 2nd edition* *Child Behaviour Checklist (CBCL)*		the lowest group (M=74.3, SD= 33) and middle group (M=76.8, SD= 32.3) Verbal IQ predicted CBCL anxiety T-Scores (β=0.04, SE =0.01) Despite these sig. findings, the effect sizes of age and verbal IQ on anxiety t-Scores appear to be negligible (r=0.14, r^2=0.03).
Hallett, V., Ronald, A., Colvert, E., Ames, C., Woodhouse, E., Lietx, S., Garnett, T., Gillan, N., Rijsdijk, F., Scahill, L., Bolton, P., & Happe, F	Journal of Child Psychology and Psychiatry	Parent-rated, between groups design (with control group)	146 families and 80 controls, identified from the Twins Early Development Study (TEDS)	*Autism diagnostic interview Revised (ADI-R)* *Autism diagnostic observation schedule (ADOS)* *Wechsler Abbreviated Scales of Intelligence (WASI)* *The Revised Child Anxiety and Depression*	Participants recruited as part of a longitudinal study of twins born in the UK between 1994 and 1996.	The only sig. correlations between IQ and anxiety were found in a positive association with parent-rated Social Anxiety (ICC=.45, p<.05) and a negative association with self-rated Separation Anxiety (ICC=-.37, p<.05)

				Scale (RCADS)		
Hallett, V., Lecavalier, L., Sukhodolsky, D.G., Cipriano, N., Aman, M.G., McCracken, J.T., McDougle, C.J., Tierney, E., King, B.H., Hollander, E., Sikich, L., Bregman, J., Anagnostou, E., Donnelly, C., Katsovich, L., Dukes, K., Vitiello, B., Gadow, K. & Scahill, L.	Journal of Autism and Developmental Disorders	Parent rated questionnaire, between groups design (no control)	415 participants recruited from one of three clinical trials conducted by the RUPP Autism Network (M=8.47, SD= 2.87)	*Vineland Adaptive Behaviour Scales* *Wechsler Preschool and Primary Scale of Intelligence- Revised* *Mullen Scales of Early Learning* *Leiter International Performance Scale-Revised* *Slosson Intelligence Test.* *CASI anxiety scale* *CASI-PDD Scale* *Aberrant Behaviour Checklist (ABC)*	Participants recruited from randomised controlled trial conducted by the Research Units on Pediatric Psychopharmacology (RUPP) network.	Children with an IQ of 70 or above were sig. more anxious (M=16.47 SD=10.26) than those with IQs below 70 (M=12.24 SD=7.94) t(390)=4.58, p<.01. Nonverbal children with IQ below 70 had even lower scores (M=10.33, SD=6.73). When adjusting for IQ there were no sig. differences in anxiety across ASD subgroups F(2,388)=2.47, p=.08
Lanni, K.E., Schupp, C.W., Simon, D. &	Autism	Experimental design (with	15 participants aged between	*Autism diagnostic observation schedule*	Details not given	Lower verbal ability in children with autism did not predict salivary cortisol or

Corbett, B.A.		control)	8 and 12.	*(ADOS)* *Pubertal Developmental Scale (PDS)* *State-Trait Anxiety Inventory for Children (STAI-C)* *WASI* *Narrative Memory subtest from NEPSY* *Verbal Fluency Test from Delis-Kaplan Executive Function System* *TSST-C*		anxiety responses
Mayes, D.S., Calhoun, S.L., Murray, M.J. & Zahid, J	Journal of Developmental and Physical Disabilities	Parent rated questionnaire, between groups design (no control)	627 Children aged 1-17 (M=6.6, SD= 3)	*WISC (II/III), WPPSI-III* *Checklist for Autism Spectrum Disorder (CASD)* *Pediatric Behavior*	Participants recruited from clinical population from an American diagnostic clinic.	Anxiety and depression increased with increasing IQ(r=.20 and .14, p<.0001) though explained variance was small (4.1% and 2.0%). Children with HFA had

				Scale (PBS)		more anxiety and depression than children with LFA (F= 20.7 and 11.1, p<.001) with small to medium effect sizes (d=0.4 and 0.3). Verbal IQ was more strongly related to anxiety and depression (r=.29 and .20 p<.0001) than nonverbal IQ (r=.12, p=.003 and r=.08m p=.037).
Niditch, L.A., Enrique Varela, R., Kamps, J.L. & Hill, T.	Journal of Clinical Child and Adolescent Psychology	Parent rated questionnaire, between groups design (no control)	231 children aged 2-9 were selected from archival data (M=5.0, SD= 2.0)	*Autism diagnostic interview Revised (ADI-R)* *Autism diagnostic observation schedule (ADOS)* *Mullen Scales of Early Learning* *Wechsler Preschool and primary Scale of Intelligence*	Participants recruited from clinical population based on referral to an American assessment centre.	Differences were found between ASD subgroups indicating that 8.6% of ASD were in the at risk range and 6.4% were in the clinical range. 10% of PDD-NOS participants were in the at risk range and 8.6 in clinical range. 20% of Asperger's participants fell in the at risk range and 10% in the clinical range.

				Wechsler Intelligence Scale for Children (WISC IV) *Leiter International Performance Scale-Revised or the Wechsler Nonverbal Measure of Ability* *Behaviour Assessment System for Children (BASC-2)*		Results demonstrated a sig. positive association between children's levels of cognitive functioning and their parents' ratings of their child's anxiety (r=.47, p<.001) Results of analysis of covariance indicated that subgroup F(1, 218)=.20was no longer a significant predictor after controlling for IQ, F (1,218)= 64.55, p<.001
Rieske, R.D., Matson, J.L., & Davis III	Journal of developmental and physical disability	Parent rated questionnaire, between groups design (no control)	2366 children aged 17-36 months (M=25.7 months, SD= 4.67)	*Batelle Developmental Inventory- 2nd Edition (BDI 2)* *Baby and Infant Screen for Children with aUtIsm Traits (BISCUIT)*	Participants recruited through community based intervention	Cognitive DQ predicted Total Anxiety Scores, β= -.36, t (198)=-5.51, p<.001 and also explained a significant proportion in the variance in Total Anxiety scores, R^2=.13, F(1,199)=30.33, p<.001

						Adaptive DQ was also found to sig. predict Total Anxiety scores, β=-.28, t (198)=-4.10, p<.001 and also explained a significant proportion in the variance in Total Anxiety scores, R^2=.08, F (1,199)=16.80, p<.001.
Simonoff E., Pickles A., Charman T., Chandler S., Loucas T. & Baird G.	Journal of the American Academy of Child and Adolescent Psychiatry	Parent rated questionnaire, between groups design (no control)	112 children (M= 11.5 years)	*Autism diagnostic interview Revised (ADI-R)* *Autism diagnostic observation schedule (ADOS)* *The Child and Adolescent Psychiatric Assessment-parent version (CAPA)*	Participants recruited from SEN database.	No relationship between intelligence and psychiatric disorders (including anxiety)
Strang, J.F., Kenworthy, L., Daniolos, P., Case, L., Wills, M.C., Martin, A. & Wallace, G.	Research in Autism Spectrum Disorders	Parent rated questionnaire, between groups design (no control)	95 children aged between 6 and 18 (M= 11.67, SD= 3.4)	*Autism diagnostic interview Revised (ADI-R)* *Autism diagnostic observation schedule (ADOS)*	Participants recruited from clinical population based on referral to an American multidisciplinary autism clinic	No significant relationships were observed between cognitive ability and emotional symptoms. Independent samples t-tests comparing elevated anxiety symptoms participants vs non-elevated anxiety

				Wechsler Intelligence Scales for Children (WISC IV) *Wechsler Abbreviated Scales of Intelligence (WASI)* *Child Behaviour Checklist (CBCL)*		symptoms participants revealed no differences between full scale IQ, verbal ability or nonverbal ability.
Sukhodolsky, D.G., Scahill, L., Gadow, K.D., Arnold, E., Aman, M.G., McDougle, C.J., McCracken, J.T., Tierney, E., Williams White, S., Lecavalier, L & Vitiello, B.	Journal of Abnormal Child Psychology	Parent-rated questionnaire, between groups design (no control)	172 children recruited from one of two clinical trials conducted by the Research Units on Paediatric Psychopharmacology (RUPP) Autism Network (M=8.2, SD=	*Autism diagnostic interview Revised (ADI-R)* *Vineland Adaptive Behaviour Scales* *Wechsler Intelligence Scales for Children (WISC III)* *Wechsler Preschool and Primary Scale of Intelligence* *Aberrant Behaviour Checklist (ABC)*	Participants recruited from randomised controlled trial conducted by the Research Units on Pediatric Psychopharmacology (RUPP) network.	Children with IQ less than 70 were less likely to meet the cut-off criteria for GAD, somatization, separation anxiety disorder or any anxiety disorder when compared to children with IQ above 70 (not social phobia, panic disorder or simple phobia). Higher levels of anxiety were associated with higher IQ (β=.18,p ,.05) the presence of functional

			2.6)	*Child and Adolescent Symptom Inventory (CASI)*		language use (β= .17, p<.05) and stereotyped behaviours (β= .23, p<.05).
White, S.W. & Roberson-Nay, R.	Journal of Autism and Other Developmental Disorders	Self-report questionnaire, between groups design (no control)	20 children aged 7-14 (M=12.08, SD= 1.78)	*Autism diagnostic observation schedule (ADOS)* *Social Communication Questionnaire (SCQ)* *Social Responsiveness Scale (SRS)* *Social Competence Inventory (SCI)* *Multidimensional Anxiety Scale for Children (MASC)* *Child Behavior Checklist (CBCL)*	Clinical sample recruited from outpatient clinic for youth with ASD	The children in the lower IQ group (n = 9) had a mean total T score of 64.44 (±16.69), compared to 49.88 ± 7.20 for the higher IQ group (n = 8)
Witwer, A.N., & Levacalier, L.	Journal of Developmental and Physical Disabilities	Parent-rated questionnaire, between groups design (no control)	61 children aged 6-17 (M=11.2, SD=3.8)	*Autism diagnostic interview Revised (ADI-R)* *Stanford-Binet-V* *Children's Interview for*	Information not given	Those with Intellectual Disability (ID) were more likely to be subsyndromal for GAD (χ^2=7.04, p=.008; n=10) versus meeting full criteria (n=3). Those

	Psychiaric Symptoms-Parent Version (P-ChIPS) *Nisonger Child Behavior Rrating Form (NCBRF)*	without ID were more likely to meet full GAD criteria (n=11) than to be subsyndromal (n-4). IQ was positively associated with the Specific Phobia Symptom 'Fear keeps from school' (χ^2=10.5, p<.001) IQ was positively associated with the GAD symptoms: 'Worry more than others' (χ^2=10.89, p<.001), 'Hard to relax when worries' (χ^2=7.32, p<.01) and 'Trouble letting go of worries' (χ^2=10.5, p<.001)

Chapter 2: Empirical Paper

An exploration of cognitive ability factors, anxiety and the physiological experience in children with High Functioning Autism (HFA)

An exploration of cognitive ability factors, anxiety and the physiological experience in children with High Functioning Autism (HFA)

Autism Spectrum Disorder is a behaviourally defined disorder which is characterised by deficits in social communication and interaction as well as repetitive and restrictive patterns of behaviour and interests (DSM-5; APA, 2013). In addition to these deficits, it has been suggested that approximately 70% of individuals with ASD suffer from additional psychiatric symptoms leading to the diagnosis of a comorbid mental disorder (APA, 2013), with anxiety disorders among the most common (see White, Oswald, Ollendick & Scahill 2009; Macneil, Lopes & Minnes, 2009; van Steensel, Bögels & Perrin, 2011 for reviews). Accordingly, prevalence rates of anxiety disorders are higher in children with ASD than in their typically developing (TD) peers. While around 3.1% of boys and 4.3% of girls (TD) in the UK are reported to experience some form of recognisable anxiety disorder (Green, McGinnity & Meltzer, 2005), research has reported rates of 11% (Lecavalier, 2006) and 84% (Muris, Steerneman, Merckelbach, Holdrinet & Meesters, 1998) in the ASD population. It has also been suggested that anxiety can be even more challenging for individuals with ASD than their peers, for example by providing additional barriers to participation and by further compounding difficulties with social functioning (White et al. 2009).

It should of course be noted that although anxiety is recognised as a specific category of disorders within the DSM, it also represents a common response to everyday experience and physiological stressors. In other words, while anxiety can be experienced at elevated levels and for extended periods consistent with a clinical diagnosis; all individuals are likely to experience some degree of stress throughout their lives which can contribute to feelings of anxiety (Mroczek & Almeida, 2008). It is therefore helpful to not consider anxiety exclusively as a disorder, but also as an emotion which can be characterised by feelings of tension, worry, physiological arousal and behavioural avoidance.

Nevertheless, while we are all susceptible to feelings of anxiety it seems likely that certain factors could lead to the increased prevalence of anxiety (and subsequent disorders) that is reported in children and young people with ASD (White et al. 2009; MacNeil et al, 2009). Models of anxiety offer a variety of explanations for these increased rates of anxiety in children with ASD. For example, it has been suggested

that anxiety may develop secondary to ASD in response to social and environmental demands made more difficult by the functional deficits associated with the condition (White et al. 2009). Moreover, risk factors for anxiety in TD children (e.g., parental stress and family conflict; Hammen, Brennan & Shih 2004; and poor peer relationships; de Matos, Barrett, Dadds & Shortt, 2003) are likely to be exacerbated for children with ASD due to increased challenges associated with the disorder.

Wood & Gadow (2010) also proposed that anxiety symptoms can develop through a variety of ASD-related stressors including increased social confusion, peer rejection, behavioural conflict in symptom expression and aversive sensory experiences. These stressors contribute to an overall level of negative affect which is then expressed through negative behaviours which are characteristic of anxiety. They can also become a specific focus of fear or anxiety through automatic forms of learning and conditioning.

Other factors may also increase the likelihood that individuals with ASD may experience elevated symptoms of anxiety. For example, cognitive ability and language skill have also been suggested to be positively associated with anxiety in children and young people with ASD (Hallett et al. 2013; Mayes et al. 2011; Estes et al. 2007; Niditch et al. 2012). More specifically, these studies indicate that children with ASD who are more cognitively able may be at increased risk for the development of anxiety due to an increased level of social understanding. For example, Niditch and colleagues (2012) argued that increased cognitive ability places children and adolescents diagnosed with ASD at increased risk of developing anxiety due to an increased awareness of their individual difficulties and social pressures combined with a lack of capacity to self-regulate or change their behaviour.

Research has also suggested that the expression of this anxiety or negative affect may vary as a function of communicative skill of verbal IQ, whereby children who are more verbally able are more likely to develop symptoms which are recognisable as anxiety, whereas children with weaker verbal skills may be more likely to resort to externalising behaviours or demonstrate specific behaviour difficulties (Niditch et al. 2012; Estes et al. 2007). These behaviour difficulties can include verbal and physical aggression, self-injurious behaviour, oppositional or defiant behaviour and difficulties with peer relationships or socialisation. While the nature of these difficulties may vary, they are all likely to serve the function of communicating or expressing underlying needs,

desires or emotions as an alternative to other more socially acceptable or appropriate means of communication. These behaviours could therefore, in some instances communicate underlying feelings of anxiety or negative affect. This idea is supported by previous research which indicates that specific behaviour difficulties such as aggressive behaviour are associated with learning and communication difficulties in childhood and adolescence (Clark, Prior & Kinsella, 2002).

However, despite these assertions, there remains some inconsistency in the research and some researchers have found evidence to suggest that these relationships (often observed in samples with a broad range of intellectual levels) do not hold true for children within the normal range of intellectual functioning (Strang et al. 2012; Eussen et al. 2013). It seems likely that some of this inconsistency will be associated with differences in sample characteristics and the heterogeneous nature of this population. However, further variation is likely to result from issues of assessment. In particular, the majority of research has relied upon questionnaire measures for the assessment of anxiety which have not been validated for use with individuals with ASD (Grondhuis & Aman, 2012). Furthermore, there is little consistency between studies in the assessment of anxiety, making it difficult to generalise between studies. Further research is therefore necessary before any firm conclusions can be drawn about the phenomenology of anxiety in young people with ASD.

Assessing Anxiety in Children with ASD

The reliable and valid assessment of anxiety in individuals with ASD can be problematic due to a range of characteristic deficits associated with the condition. In particular, communication difficulties and deficits in emotional awareness or recognition, which may impact on the ability to accurately express feelings of anxiety to others.

While there is great variation in the development of language and communication in individuals with ASD, it is widely accepted that many individuals with ASD begin to speak late and develop speech at a significantly slower rate than their peers (Tager-Flusberg, Paul & Lord, 2005). Specific difficulties include challenges with articulation (Kjelgaard & Tager-Flusberg, 2001), as well as delays in expressive and receptive language (Kjelgaard & Tager-Flusberg, 2001; Charman, Drew, Baird & Baird, 2003).

Accordingly, communicative ability can vary greatly in young people with ASD ranging from non-verbal to highly verbal but difficulties with the pragmatic aspects of language.

Although some children with ASD have been shown to score well on standardised vocabulary tests (Kjelgaard & Tager-Flusberg, 2001), certain classes of words tend to be underrepresented in the vocabulary of children with ASD. For example, Tager-Flusberg (1992) found that children used fewer mental state terms than their peers. Other researchers have found that children with ASD have particular difficulties understanding social and emotional terms (Eskes, Bryson & McCormick, 1990). This will inevitably have implications on the assessment of anxiety within this population.

The concept of emotion is complex and the presence of an emotional state does not necessarily imply emotional awareness. Instead, the awareness of an emotion is dependent on the recognition of bodily and behavioural signals in combination with the evaluation of the current situation where they arise and a knowledge and understanding of emotional vocabulary (Rieffe, Meerum Terwogt & Kotronopoulou, 2007). Accordingly, for an individual to be able to accurately label an emotion they need to be able to both recognise and monitor their own internal states and be aware of what this means in a given situation. Rieffe et al. suggest that in normal development, this understanding occurs naturally through processes of self-monitoring, the observation of others and through information provided by the (verbal) community. However, it is possible that these learning routes may be less accessible for children and adolescents with ASD; in support, Rieffe et al. (2007) found evidence to suggest that children with ASD had difficulties recognising their own emotions and tended to have less developed emotion concepts.

Lambie and Marcel (2002) proposed a theoretical framework for emotional experience that makes a distinction between first order experience, which involves the neurophysiological arousal associated with emotion and second-order experience, which is the awareness of this arousal. This framework effectively suggests a decoupling of the physiological arousal associated with emotion and its conscious representation. Evidence has been found to suggest that this first order experience is associated with the amygdala and orbitofrontal cortex (Ochsner & Gross, 2005) and that second order awareness is associated with the insular-somatosensory and anterior cingulate cortices, in particular anterior insula activation (Craig, Chen, Bandy & Reiman, 2000). This

latter region of the brain is highly interconnected and plays a crucial role in the experience of emotion derived from information about bodily states. In particular, evidence has been found indicating strong links between the anterior insula and perception of bodily stare and experience of emotion (Critchley, Wiens, Rotshtein, Ohman & Dolan, 2004). Anterior insula activation has also been observed to be significantly higher in anxiety positive participants when compared to anxiety normative controls (Simmons, Stein, Strigo, Arce, Hitchcock & Paulus, 2011).

In a comprehensive meta-analysis of functional neuroimaging studies of social processing in ASD, DiMartino, Ross, Uddin, Sklar, Castellanos and Milham (2009) found evidence to suggest significant hypoactivity in the right anterior insula of children with ASD. This suggests that although individuals with ASD may experience similar levels of physiological arousal to their peers, they may lack conscious awareness of these feelings or emotions. It therefore seems possible that these underlying differences in neurophysiology could underpin difficulties in emotion processing in individuals with ASD that limit that individual's ability to monitor and report on emotional states.

Because of these underlying difficulties, previous studies that have explored anxiety in individuals diagnosed with ASD have often used parent-reported measures of anxiety. However, these may also be inappropriate and could potentially have further implications on the reliability and validity of the findings of these studies.

Previous research has indicated that different informants' ratings of social, emotional or behavioural problems in children are often discrepant (Achenbach, McConaughy & Howell, 1987) and unreliable. This means that parent rated anxiety is likely to differ from self-reported anxiety and indeed, parent-child agreement has been shown to be poor for children with ASD. For example, researchers have now provided evidence to suggest that parent-child agreement of anxiety symptoms in children with ASD is generally low with parents often rating anxiety higher than their children (Blakeley-Smith, Reaven, Ridge & Hepburn, 2012; Gillott, Furniss & Walker, 2001). This could therefore indicate that the higher rates of anxiety observed in children with ASD may be driven by the different methodological approaches taken in these studies and the dependence on parental report measures.

De Los Reyes and Kazdin (2005) highlighted a range of child and parent characteristics which could potentially contribute to these informant discrepancies. For

example age differences were identified where correlations between informants' ratings were greatest for children aged 6-11, but weaker for children aged 12-19. They suggested that this could be because younger children's behaviour may be more observable or because they spend more time with their parents. They also suggested that discrepancies may increase or decrease as the child's self-presentation concerns increase. These factors may be especially pertinent for children with ASD who may spend more time with their parents due to differences in cognitive and social development and may be less concerned about how they present themselves to others. Moreover, it has also been suggested that children with ASD are likely to engage in more externalising behaviour when anxious when compared to their TD peers (Evans, Canavera, Kleinpeter, MacCubbin & Taga, 2005). This means that anxiety symptoms may be more observable in these individuals.

In addition, De Los Reyes and Kazdin also suggested that parent characteristics and family dynamics are likely to play a crucial role in the level of agreement between different informants. In particular, parental reports of emotional symptoms or psychopathology have been shown to vary as a function of parental depression (Chi & Hinshaw, 2002), parental anxiety (Krain & Kendall, 2000) and stress (Kolko & Kazdin, 1993). Again, these factors could contribute to the seemingly elevated rates of anxiety in children with ASD as levels of parental anxiety, depression and stress have been shown to be higher in families of children with developmental disabilities such as ASD (Ritzema, & Sladeczek, 2011).

Cortisol and Anxiety

Given the inherent difficulties in measuring subjective emotional states in individuals with ASD using parent and self-report measures, researchers have begun to explore the use of more objective, physiological measures of anxiety in order to gain a more accurate representation of how anxiety is experienced within this population.

Cortisol secretion is associated with the Hypothalamic-Pituitary-Adrenocortical (HPA) system and activation within this region has also been shown to reflect increased levels of arousal and stress (Corbett, Schupp, Levine and Mendoza, 2009). The regulation of this system involves three interrelated processes (1) The maintenance of a diurnal rhythm; (2) activation in response to stress or threat and (3) Restoration of basal activity via negative feedback mechanisms (Corbett et al. 2009). Cortisol follows a

circadian rhythm with highest concentrations in the morning and a decline throughout the day. The lowest levels are in the evening and at night. An example of typical cortisol awakening response is illustrated in Figure 3.

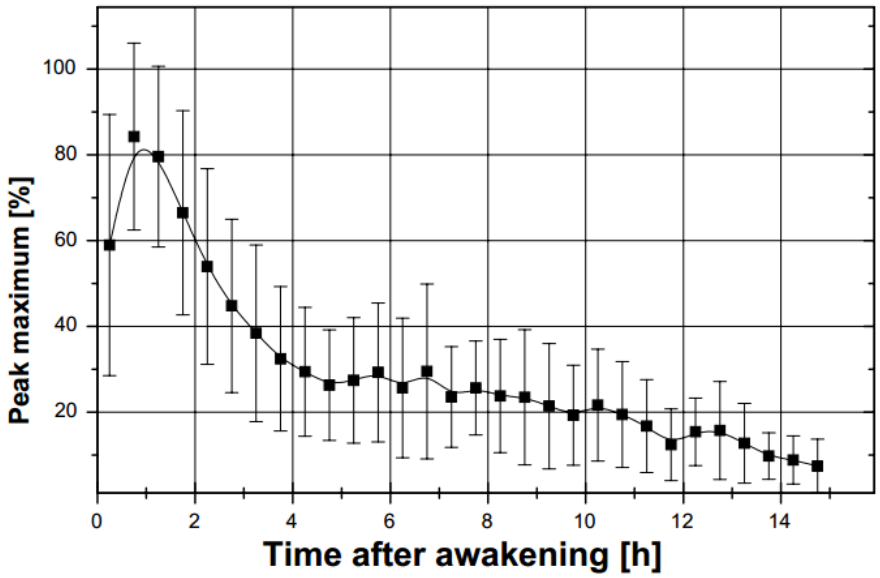


Figure 3: Typical cortisol awakening response (Westerman, Demir & Herbst, 2004). Black squares indicate the mean (n=110) and the bars indicate SD range.

Cortisol is commonly used as a physiological measure of state anxiety in experimental studies. It is the primary human glucocorticoid hormone and is essential for glucose regulation (Buchanan, al'Absi & Lovallo, 1999). Moreover, its secretion is associated with psychological stressors including anxiety (Takai, Yamaguchi, Aragaki, Eto, Uchihashi & Nishikawa, 2004; Schlotz, Schulz, Hellhammer, Stone & Hellhammer, 2006). In a comprehensive meta-analysis of 208 laboratory studies, Dickerson and Kemeny (2004) found that psychological stressors led to an increase in cortisol levels. More specifically, tasks containing both uncontrollable and social-evaluative elements were associated with the largest cortisol changes and the longest times to recovery. Cortisol has been used to measure stress-related physiological change has been used successfully with ASD populations and researchers have demonstrated an elevated cortisol response after exposure to a non-social stressor in children with ASD when compared to a TD group (Corbett, Mendoza, Abdullah, Wegelin & Levine, 2006).

Study Aims

The aim of this study was to explore associations between anxiety and cognitive and language ability factors in adolescents with ASD. It also explored how anxiety is experienced physiologically and whether this relates to existing anxiety measures and the self-reported experience of anxiety in adolescents with ASD across a school day. More specifically, an experience sampling technique was employed alongside the concurrent collection of salivary cortisol to carefully explore potential differences in physiological arousal and self/parent-reported anxiety between secondary aged school children with ASD compared with a typically developing group of adolescents. The primary research questions were as follows:

- Is nonverbal ability associated with increased anxiety in adolescents with HFA?
- Is verbal ability associated with increased anxiety in adolescents with HFA?
- Is nonverbal ability associated with increased behaviour difficulties in adolescents with HFA?
- Is verbal ability associated with increased behaviour difficulties in adolescents with HFA?
- Do questionnaire measures correlate with the physiological experience of anxiety of experience sampled anxiety?
- Are there differences between groups in physiological arousal?

The study's objectives were to inform future research into anxiety and its assessment in an ASD population. Following previous research it was hypothesised that adolescents with ASD would experience higher levels of physiological arousal across the school day (Corbett et al. 2006), but that this relationship would be less evident in self-report. It was also hypothesised that adolescents with ASD would score higher in measures of social anxiety than their TD peers, and that scores for social anxiety and general worries would increase with increasing cognitive ability due to an increased level of understanding or awareness of social challenges and demands, while behaviour difficulties were predicted to decrease with increasing verbal ability. Moreover, it was predicted that agreement between measures would be stronger for TD participants than for adolescents with ASD.

Method

Design

This exploratory study used a between groups design to compare differences in state and trait anxiety responses between a group of adolescents with ASD and a comparison TD group in a school setting.

Participants

9 Participants with ASD and 7 TD controls were recruited from three UK secondary mainstream school resourced provisions by process of self-selection. A total of 20 adolescents with ASD were invited to take part in the present study, but seven declined to participate and four did not reply. All participants were male and were currently accessing a mainstream curriculum. ASD participants were aged between 12 and 16 (M= 14 years 11 months, SD= 1 year) and had received a clinical diagnosis of ASD in order to access the resourced provision. The Social Communication Questionnaire (Rutter, Bailey & Lord, 2003) was used as an additional screen for autism symptoms. A cut off score of 15 was used as recommended by the authors and all ASD participants exceeded this score (M= 21, SD= 3.02).

A control group (n=7) without an ASD diagnosis was also recruited to take part from the same settings (Age; M= 13 years 3 months, SD= 1 year 4 months). This group was identified by school staff to match ASD participants as closely as possible, i.e similar academic ability and age group. 10 typically developing adolescents were invited to take part, but three declined.

Measures

Screening

Social Communication Questionnaire (SCQ)

The SCQ (Lifetime Version) (Rutter, Bailey, & Lord, 2003) was used as a screening tool for participants in the ASD group. This measure is designed to screen for ASD and consists of 40 yes or no questions relating to communication skills and social

functioning. Its content parallels that of the Autism Diagnostic Interview- Revised (ADI-R) and therefore offers a brief but reliable screening tool. The authors recommend a threshold raw score of >15 when identifying children with ASD. All ASD participants need to meet these criteria for inclusion in the study. This scale has been found to have good discriminant validity and utility as an efficient screener for at-risk groups of school-age children (Rutter, Bailey, & Lord, 2003).

Cognitive Ability and Language

The Raven's progressive matrices (RPM)

The RPM (Raven, Raven & Court, 1998) was used as a measure of non-verbal cognitive ability. This assessment is relatively simple and efficient to administer and consists of 60 items grouped within 5 sets. The RPM is made up of a series of diagrams or designs with a part missing. Participants are asked to select the correct piece from a number of options. It provides a simple but effective measure of cognitive ability (represented as standard score) which has been shown to have good internal consistency reliability and high convergent validity with a range of existing measures. For example, scores from the RPM have been found to correlate with scores on the subtests of the Wechsler Adult Intelligence Scale (WASI III; The Psychological Corporation, 1997).

The Mill Hill Vocabulary scale (MHVS)

The Mill Hill Vocabulary scale (Raven, Raven & Court, 1998) provides an accompanying measure of verbal ability. It does need to be noted that this measure assesses only vocabulary; however this serves as a proxy to verbal IQ and has been shown to correlate with existing measures of intelligence (Court & Raven, 1995; Raven, 2000). It therefore provides a brief, yet reliable measure of communicative skill or ability. This test consists of 88 words arranged in order of ascending difficulty. Participants are required to either explain the meaning of these words or to select the correct synonym of the word from a list of six alternatives. This scale was standardised alongside the RPM and has been found to have good internal consistency and reliability.

Anxiety

Spence Children's Anxiety Scale (parent and child versions)

The Spence Children's Anxiety Scale (SCAS; Spence, 1998) provides a child self-report and parent report measure designed to assess symptoms relating to separation anxiety, social phobia, obsessive compulsive, panic/agoraphobia, physical injury fears and generalized anxiety. This measure is appropriate for children aged 7 to 16 years consists of 44 (child version) and 38 (parent version) items that are responded to by indicating the frequency with which they experience the symptom; never, sometimes, often, always to create a total anxiety score between 0 to 114 for both child and parent measures. This measure has been found to have good convergent validity and test-re-test reliability (Essau, Sasagawa, Anastassiou-Hadjicharalambous, Guzmán & Ollendick, 2011; Spence, Barrett & Turner, 2003). In the present study internal consistency was high for both child and parent versions (α=.735 and .742). For the present study, total anxiety scores and individual domain scores will both be explored. In addition to raw scores, T-scores were also calculated for each participant. These scores are rescaled so that T-scores have a mean of 50 and a standard deviation of 10, therefore allowing for the comparison of a young person's scores against norms from an equivalent age and gender group. Scores within one standard deviation (ie. a T-score of 10) above the mean on any dimension are regarded as being within the normal range on that dimension.

Experience Sampling

Hewlett Packard iPaqs were used to prompt participants at random intervals (minimum interval 30 minutes, maximum interval 90 minutes) to rate their current anxiety levels and positive affect (happiness) using a sliding scale from 0-10. They were also prompted to provide information as to their current activity and the number of people with them from a series of multiple choice questions. Additional information was also asked for regarding factors which may influence cortisol levels (recent food intake or exercise). Data was scored by the participant and recorded in a data file on the palm pilot.

Cortisol

To complement the self-reported feelings of anxiety and positive affect, saliva samples were collected at each data point using a synthetic salivette to provide a measure of salivary cortisol. These samples were individually labelled and assigned a code to correspond to each datapoint. Cortisol assays were sent for analysis at the University of Trier, Germany. For the present study correlations were explored between self-reported anxiety or positive affect and cortisol at each datapoint, as well as associations between cortisol levels across the day, cognitive factors, anxiety scores and behaviour difficulties.

Behavioural Difficulties

Strengths and Difficulties Questionnaire (SDQ)

The SDQ (Goodman, 1997) is a brief behavioural screening tool which can be used to assess a range of behaviour difficulties including conduct problems, hyperactivity/inattention and peer relationship problems. It also provides a measure of prosocial behaviour. A total difficulties score can also be obtained by summing all scales except prosocial behaviour. The SDQ consists of 25 items that are responded to by indicating the level of agreement; not true, somewhat true, certainly true to create a total score from 0 to 40. Scores above 17 are described as "abnormal" and may be used to identify possible mental health disorders. This measure is appropriate for children aged 4-16 and is available in self-report, teacher report and parent report forms. This study used the parent version. It has been shown to have good construct validity (Van Roy, Veenstra & Clench-Aas, 2008) and internal consistency (Goodman, 2001). It has also been demonstrated to correlate with other measures of child behaviour including the CBCL (Goodman & Scott, 1999). In the present study internal consistency was high (α=.727).

Procedure

Before the study commenced consent for participation was obtained from each school's Headteacher. Opt-in consent letters and participant information (see Appendix E) sheets with details about the study, confidentiality and right to withdraw were then sent to parents of pupils. A further information sheet for young people (see Appendix F) was also provided for pupils providing information about the study. All pupils from

three ASD resource bases were invited to take part and potential TD participants were identified by school staff.

Prior to data collection, participants' parents were asked to complete the Spence Children's Anxiety Scale (parent version) and the Strengths and Difficulties Questionnaire (SDQ). Parents of ASD participants were also asked to complete the Social Communication Questionnaire (SCQ). In most instances these questionnaires were completed by parents and returned to school, however five parents' responses were collected over the telephone with the experimenter reading individual questions. Participants were then asked to complete the child version of the Spence Children's Anxiety Scale.

Following the completion of these initial questionnaires, participants completed the Raven's Progressive Matrices (Standard Progressive Matrices- Plus Version) and the Mill Hill Vocabulary Scale. These tests were administered individually by the researcher in a quiet room in school, during one session lasting approximately 40-60 minutes

After completing these measures, data collection relating to experience sampling took place over two consecutive school days. Each day participants were provided with 8 synthetic salivettes in a sealed bag and an iPaq palm pilot. These devices were programmed to prompt the participant at 8 random intervals across the school day (minimum interval 30 minutes, maximum interval 90 minutes) to rate their anxiety and affect using a sliding scale, rated from 0-10. Further questions collected additional information corresponding to their current activity and social status (the number of people with them). A maximum total of 16 measurements were taken per participant across the 2 days.

At each data point, participants were also prompted to provide a saliva sample as a measure of cortisol. These samples were collected using a synthetic salivette (numbered sequentially to correspond to individual time points). Participants were prompted to chew on this salivette for 20-30 seconds and return it to its container. Cortisol samples were labelled by code and refrigerated on-site for the duration of the data collection. Samples were then frozen prior to shipment and sent for analysis at the University of Trier, Germany.

Adherence for this study was generally good. 8 participants complete all 16 measurements (100%), and a further 7 completed 11-15 measurements (68.75%-93.75%). Measurements were not included if palm pilot responses were incomplete, or if saliva samples were not sufficient to detect cortisol. One participant decided to withdraw after one day. This resulted in an overall adherence rate of 90.63%.

Ethics

Ethical approval was obtained from the University of Southampton's ethics committee and Research Governance Office (see Appendix D). Permission to use questionnaires was obtained from test authors.

Results

Prior to data analysis, exploration of dependent variable measures showed that SCAS (child) raw scores were not normally distributed (Shapiro-Wilk <.9, $p < .05$). All other variables were found to be normally distributed and to have homogeneity of variance (Z <1.0, $p > .05$). Exploration of experience sampling variables showed that anxiety and positive affect (mood) were not normally distributed for either group (in all cases Kolmogrov Smirnov $Z < 1.5$ $p < .05$). Cortisol was normally distributed for both groups (in both cases $Z > 1.75$, $p < .01$). Although not all data was normally distributed t-tests were still deemed to be appropriate as visual inspection of data still indicated a relatively symmetrical distribution and mean scores sat within the centre of this distribution.

Sample Characteristics

Participants included in this study were aged between 12 and 16 years (M=14years 3 months, SD= 1 year 5 months). Ages in the ASD group ranged between 12 years 5 months and 16 years. The TD group were aged between 12 years and 15 years. Cognitive ability was assessed for all participants using the RPM (nonverbal ability) and MHVS (verbal ability). Mean standard scores for these assessments were 90.31 (SD= 12.97) and 101.88 (SD= 12.76) respectively. There were significant differences found between the ASD group and TD group for the RPM ($t(14) = 2.62$, $p = 0.20$) indicating that children in the ASD group scored higher (M= 96.67, SD= 10.89) than

those in the TD group (M= 82.14, SD= 11.13). No significant group differences were found between scores in the MHVS.

In the present sample, mean anxiety t-scores as rated by the SCAS were 54.69 (SD=11.22) for the parent version and 51.75 (SD= 12.82) for the child version. In the ASD group five (55.6%) participants were identified to have elevated anxiety scores. Only one (14.3%) TD participant was identified to have elevated anxiety scores. The mean total score for the SDQ was 13.5 (SD= 7.52). There were no significant differences between groups for either parent or child versions of the SCAS, however significant differences were identified between the SDQ ($t(14) = 2.785$, $p = .015$) indicating that children in the ASD group received higher total scores. Full sample characteristics are provided in Table 2.

Parent-child agreement between the SCAS (total anxiety score) was weak for both the ASD group and TD group ($p > .05$). However, for children in the ASD group parents scored children higher (M=28.56 Vs 25.22), whereas children in the TD group scored themselves higher than their parents did (M= 25 Vs 20.43). These findings were both significant at the 0.05 level. Further correlations were also explored for each subscale indicating that parent-child agreement was weak for all subscales, with the exception of physical injury fears (TD group only).

While no significant differences were observed between groups for either parent or child versions of the SCAS, further analyses were undertaken to explore differences in different domains (see Table 3). As a result three significant differences were identified between groups indicating that children with ASD received higher scores in the Social Phobia ($t(14) = 2.204$, $p = 0.045$), Obsessive Compulsive ($t(14) = 2.316$, $p = 0.036$) and Generalised Anxiety Disorder ($t(14) = 2.794$, $p = 0.014$) subscales (parent versions).

Table 2 *Sample characteristics, The mean (±SD) and range of age (in years and months), cognitive ability, anxiety and behaviour difficulties scores for adolescents diagnosed with ASD, typically developing participants and totals with significant differences highlighted*

Group	**ASD (*n=9*)**			**TD (*n=7*)**			**Total (*n=16*)**		
Age	14:1	± 1:0	12:5-16:0	13:3	± 1:4	12:0-15:7	14:3	± 1:5	12:0-16:0
Cognitive Ability									
RPM Standard Score *	96.67	± 10.90	80-115	82.14	± 11.13	65-95	90.31	± 12.97	65-115
MHVS Standard Score	104.44	± 13.33	90-135	98.57	± 12.15	80-120	101.88	± 12.76	80-135
Anxiety									
SCAS (Child)									
Raw Score	28.56	± 13.25	6-71	20.43	± 15.76	5-66	25.13	± 20.13	5-71
T-Score	52.67	± 11.91	35-75	50.57	± 14.81	34-72	51.75	± 12.82	34-75
SCAS (Parent)									
Raw Score	25.22	± 19.02	12-47	25.00	± 23.04	3-51	28.38	± 15.66	3-51
T-Score	59.22	± 8.27	44-66	48.86	± 12.36	31-67	54.69	± 11.22	31-67
Behaviour difficulties									
SDQ Total Score *****	17.33	± 7.65	4-28	8.57	± 3.60	3-13	13.50	± 7.52	3-28

* *p<.05*

RPM= Ravens Progressive Matrices; MHVS= Mill Hill Vocabulary Scale; SCAS= Spence Children's Anxiety Scale; SDQ= Strengths and Difficulties Questionnaire

Table 3 *The mean (±SD) and range for anxiety subscale t scores (SCAS) and behaviour difficulties (SDQ) for the adolescents diagnosed with ASD (left side of table) and typically developing adolescents (right side of table).with significant differences highlighted*

Scale	ASD (*n=9)*			TD (*n=7)*		
SCAS- Parent						
Panic Attack	54.56	±9.34	40-66	47.14	±6.99	40-60
Separation Anxiety	57.33	±12.59	40-71	53.43	±10.83	40-69
Physical Injury Fears	57.56	±11.83	40-80	58.00	±12.75	40-71
Social Phobia*	62.00	±11.76	40-85	49.57	±10.39	40-70
Obsessive Compulsive*	58.56	±10.58	42-85	47.14	±8.60	40-65
Generalised Anxiety Disorder*	55.11	±7.91	45-75	44.86	±6.49	40-57
SCAS- Child:						
Panic Attack	49.78	±10.57	40-70	49.29	±13.00	40-69
Separation Anxiety	47.78	±9.72	40-70	53.57	±10.69	40-65
Physical Injury Fears	53.22	±14.86	40-85	54.29	±12.08	40-69
Social Phobia	52.44	±13.16	40-75	49.71	±11.35	40-68
Obsessive Compulsive	57.78	±17.34	40-85	55.14	±21.57	40-100
Generalised Anxiety Disorder	57.22	±11.76	40-70	58.29	±10.27	40-70
SDQ:						
1. Total	17.33	±7.65	4-28	8.57	±3.60	3-13
2. Conduct Problems	2.33	±2.45	0-8	.71	±1.11	0-3
3. Hyperactivity	5.22	±3.46	0-10	3.29	±2.93	0-8
4. Peer Problems	3.89	±2.93	0-8	2.57	±1.90	0-5

* *p<.05*

SCAS= Spence Children's Anxiety Scale; SDQ= Strengths and Difficulties Questionnaire

Experience sampling

Palmtop data was explored by first considering the relationship between key variables including self-reported anxiety (rated from 0-10), self-reported positive affect (rated from 0-10), cortisol, whether the current activity is structured (in lesson) or unstructured (in break, between lessons or at lunch) and the social status –whether the participant was alone, in a small group (1-5) or in a large group (6 or more).

There were 232 data points across participants (n = 134 data points for the 9 adolescents with ASD, range = 12 – 16 and 98 data points for 7 typically developing group of participants, range = 8-16). The number of data points for each participant ranged from N = 8 to N = 16 (mean = 14.5, SD = 2.31; note that for one participant data was collected only for one day). Descriptive statistics for each group for the palmtop data is shown in Table 4 illustrating mean cortisol scores and self-reported anxiety and mood for each group. In addition to this data, the area under the curve was also calculated for every individual by plotting cortisol across 12 possible time plots (see Table 6). This provides an overall cortisol level for each participant and therefore illustrates physiological arousal across the school day. To allow comparison of data between participants, the reported activity was recorded as either structured (in lessons) or unstructured (in break, between lessons or at lunch) and social status was grouped as alone in a small group (1-5) or in a large group (6 or more). This made it possible to compare frequencies and to explore associations between activity and self-reported anxiety data.

A preliminary analysis of this palm-pilot data indicated that participants in the ASD group rated themselves as more anxious (M= 3.34, SD= 2.66) than the TD group (M= 1.31, SD= 2.05) at each data point ($t(14) = 2.148$, $p=0.05$). ASD participants also scored lower at each data point for positive affect (M= 7.06, SD= 2.67) than the TD group (M= 8.52, SD= 2.48) ($t(14) = 2.998$, $p=0.01$) indicating that ASD participants were less happy than TD participants. There were no group differences identified between either activity or social status, indicating that adolescents with ASD engaged in similar levels of social interaction to their TD peers.

Table 4 *The mean (±SD) and range for the anxiety and mood questions and cortisol level for the ASD and typical groups, and the frequency of responses for activity (structured and unstructured), social status (alone, or in a small or large group)*

Measure	**ASD (n = 134 data points)**			**Typical (n = 98 data points)[1]**		
Emotion measures						
Anxiety	3.34	±2.66	0-10	1.31	±2.05	0-10
Positive Affect	7.06	±2.67	0-10	8.52	±2.48	0-10
Cortisol	7.05	±5.30	0-25.9	5.12	±4.04	0-18.2
Activity	Structured		Unstructured	Structured		Unstructured
	98		36	69		25
Social status	*Alone*	*Small group*	*Large group*	*Alone*	*Small group*	*Large group*
	20	84	30	15	34	45

[1]n = 7 missing data points for the typical group due to incomplete data.

Further analyses were carried out to explore associations between key variables (see Table 5). In order to consider the relationship between activity type and anxiety/affect, social status and structure were assigned numerical values whereby higher numbers indicated larger social groups and increased structure respectively. These correlations indicated a significant negative correlation between self-reported anxiety and positive affect (mood) for both ASD and TD participants ($p<.01$) indicating that participants who rated themselves as more anxious would rate themselves lower for positive affect at any given data point. For ASD participants another significant negative correlation was identified between current activity and social status ($p<.01$), showing that ASD participants reported being with fewer people during unstructured times. For TD participants, additional correlations were identified between positive affect (mood) and both activity and social status indicating that they reported themselves as happier in unstructured time and in larger groups. No significant correlations were identified between cortisol scores and self-reported anxiety or affect for either group.

Table 5 *The associations between the anxiety and mood questions and cortisol level, level of activity structure and social status (alone, or in a small or large group) for the adolescents diagnosed with ASD (top of table) and typically developing adolescents (bottom of table).*

	1	2	3	4	5
ASD (n=9)					
1. Anxiety	--	-.84**	-.05	.02	-.03
2. Mood		--	.09	.04	.02
3. Cortisol			--	-.02	-.11
4. Activity				--	-.24**
5. Social status					--
TD (n=7)					
1. Anxiety	--	-.36**	.08	-.06	.10
2. Mood		--	.02	.21*	.20*
3. Cortisol			--	.11	-.02
4. Activity				--	.14
5. Social status					--

$^{*}p<.05$, $^{**}p<.01$

To explore differences between cortisol variation across the day between groups, data was first plotted across the school day for each group (See Figures 4 and 5). Differences were then observed in the data, whereby cortisol concentrations were shown to decrease across the school day for children in the TD group, however the opposite pattern was observed in the ASD group. In other words, cortisol concentrations actually increased across the school day. This observation contrasts existing research and therefore further interpretations may need to be treated with caution. Full details of cortisol variation across each day for each participant can be found in Appendix G. Further analyses were also undertaken to explore cortisol responses and parameters (mean cortisol, baseline, peak cortisol and time to peak cortisol) across the day for each participant (see Table 6). This data illustrates the resting baseline cortisol level for each participant (taken at the start of the school day), the highest level recorded across the day for each participant and also provides two values to highlight the overall level of

arousal across the school day for each participant (mean and AUC). This therefore helps to illustrate the patterns of physiological arousal experienced across the school days for each group. This data highlighted significant differences between groups for peak cortisol levels indicating that adolescents with ASD demonstrated the highest cortisol levels across the experimental period and therefore the most reactivity to stressors. However, no significant differences were identified between groups for baseline, area under the curve or mean cortisol levels indicating a similar level of overall arousal for each group.

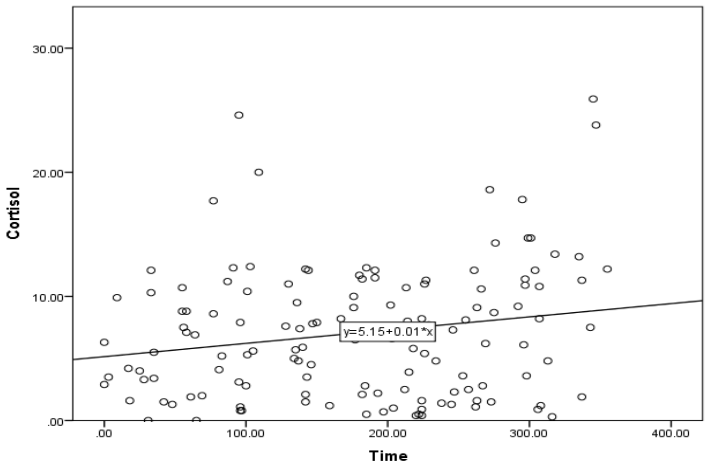


Figure 4: Cortisol variations across the day in ASD participants. Time represented in minutes past baseline.

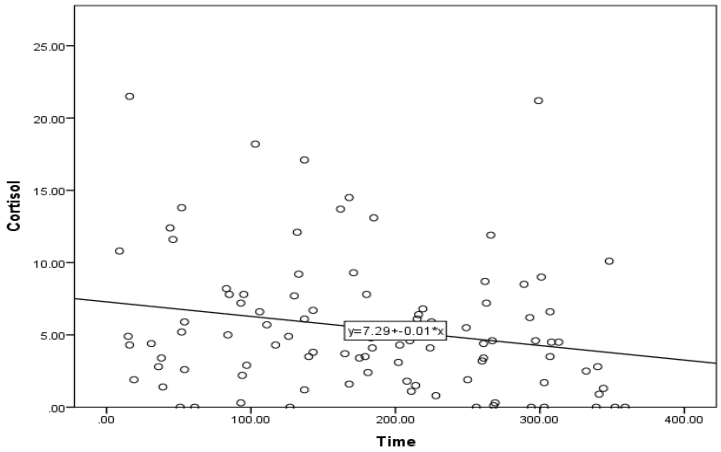


Figure 5: Cortisol variations across the day in TD participants. Time represented in minutes past baseline.

Table 6 *Descriptive summary statistics of the mean (±SD) cortisol responses and derived cortisol parameters, including baseline, mean, area under the curve and peak cortisol (for individual participants; P1-P9 = ASD, P10-P16 = TD) and by group.*

Characteristics	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	ASD	TD
Baseline	5.35	7.05	9.55	7.05	5.55	6.70	3.80	2.45	4.90	10.75	5.40	7.95	8.65	7.60	7.20	2.65	5.82	7.17
	±5.35	±1.65	±0.75	±5.05	±1.55	±3.20	±0.40	±0.85	±1.70	±0.00	±5.40	±3.65	±3.75	±6.20	±0.80	±0.75	±1.95	±2.37
Average	7.83	6.31	7.4	8.41	7.40	7.69	5.67	7.43	5.11	11.63	5.99	6.15	4.99	4.79	4.02	3.91	7.30	5.93
	±5.19	±4.50	±6.06	±6.69	±5.52	±6.05	±3.93	±3.99	±3.39	±7.35	±5.44	±3.29	±4.40	±3.40	±2.60	±2.10	±7.03	±2.46
AUC	1683.6	1544.6	4059.8	1786.5	1872.5	1693.1	1434.5	1412.4	1938.28	477.5	2524.5	1150.9	1525.6	1191.9	703.8	482.1	1936.1	1150.9
																	±816.9	±722.2
Peak cortisol	16.00	13.05	17.60	12.10	18.20	18.15	10.50	12.20	10.85	21.50	14.00	9.85	12.25	11.25	8.15	6.65	14.29	11.95
	±1.70	±1.65	±6.20	±0.00	±0.40	±6.45	±1.90	±0.10	±0.05	±0.00	±7.20	±3.25	±0.15	±2.55	±0.35	±0.55	±3.00	±4.52
Time from baseline to peak cortisol (minutes)	176.50	298.00	264.50	95.50	283.50	137.50	90.00	164.50	302.00	0.00	259.00	246.00	66.00	131.00	187.00	200.00	201.33	155.57
	±99.50	±1.00	±82.50	±95.50	±11.50	±42.5	±13.00	±20.50	±5.00	±0.00	±40.00	±61.00	±66.00	±131.00	±132.00	±63.00	±81.55	±88.37

AUC= Area under the curve

Relationships between Measures

Further correlations were carried out to explore associations between anxiety measures (questionnaire and self-report) and measures of behaviour difficulties (SDQ) for each group (see Tables 7 and 8). In order to consider the relationship between experience sampled data and questionnaire measures (SCAS, SDQ), mean anxiety, mood and cortisol scores were calculated across the two experience sampling days for each individual (e.g., total anxiety score/ number of data points). In addition, an additional cortisol measurement was calculated for each individual participant linked to area under the curve (AUC) (reflecting cortisol level across time point for each individual).

No significant correlations were observed for either group between mean cortisol scores and any measure of anxiety or behaviour difficulty. For ASD participants however, a positive correlation was identified between cortisol AUC and conduct problems (r=.68, p<.05) as assessed by the SDQ. This indicates that adolescents with ASD who demonstrated higher levels of cortisol across the school day were also reported to experience more conduct problems. Further positive correlations were identified for adolescents with ASD between the SCAS (child version) and mean experience sampled anxiety (r= .81, p<.01) and between cortisol (AUC) and mean experienced sampled affect (r= .77, p<.05) indicating that ASD children who rated themselves more anxiously during experience sampling technique also scored themselves higher on the SCAS and that ASD participants with higher levels of cortisol across the school day also rated higher positive affect. For TD participants a positive association was also observed between total scores on the SCAS (child version) and the SDQ total score (r= .89, p<.05) indicating that TD participants who scored higher in anxiety also demonstrated greater behaviour difficulties.

Further analyses were also undertaken to explore correlations between anxiety and behaviour difficulties subscales and experience sampled measures (anxiety, affect and cortisol). For participants with ASD positive associations were identified between mean experience sampled anxiety and both parent rated generalised anxiety (SCAS) and self-report social phobia (r=*.73* and r=*.78* respectively, p<.05). For the TD group, positive correlations were identified between the hyperactivity subscale of the SDQ and SCAS

(child version) total scores, and social phobia and generalised anxiety disorder subscales (r=.*77*, r= .*92* and r=.*84* respectively, p<.05).

Table 7: *Associations between measures of cognitive ability, anxiety (total score, social phobia and generalised anxiety disorder subscales) and behaviour difficulties (total scores and subscales) for ASD participants*

Measure	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
Cognitive Factors																
1. RPM	-	.31	.01	.04	-.48	-.21	-.56	.15	.27	-.18	-.34	.91**	.15	-.62	.19	.45
2. MHVS		-	-.15	.24	-.32	.13	.38	.40	.31	-.18	.30	.12	.05	-.02	.18	-.19
Anxiety																
SCAS (Child)																
3. Total			-	.86**	.79*	.38	-.06	.33	-.28	-.35	-.07	-.03	-.17	-.48	.81**	-.49
4. Social Phobia				-	.59	.30	.10	.29	-.15	-.35	-.02	-.04	-.27	-.32	.78*	-.66
5. Generalised Anxiety Disorder					-	.54	.38	.30	-.39	-.15	.12	-.47	.09	-.07	.58	-.41
SCAS (Parent)																
6. Total						-	.65	.51	.16	.15	.65	-.23	.60	-.07	.53	-.15
7. Social Phobia							-	.26	-.03	.09	.55	-.61	.47	.40	.06	-.19
8. Generalised Anxiety Disorder								-	.56	.32	.65	.17	.21	.04	.73*	-.31
Behaviour Problems																
SDQ:																
9. Total									-	.80*	.67*	.47	.13	.35	.23	-.12
10. Conduct Problems										-	.61	.12	.21	.68*	.03	-.03
11. Hyperactivity											-	-.20	.22	.44	.30	-.41
12. Peer Problems												-	.16	-.49	.14	.39
Cortisol																
13. Mean Cortisol Score													-	-.08	.00	.63
14. AUC														-	-.25	.77*
Experience Sampling																
15. Mean anxiety															-	-.48
16. Mean affect																-

* *p<.05* ***p<.01*

AUC= Area under the curve; SCAS= Spence Children's Anxiety Scale; SDQ= Strengths and Difficulties Questionnaire

Table 8: *Associations between measures of cognitive ability, anxiety (total score, social phobia and generalised anxiety disorder subscales) and behaviour difficulties (total scores and subscales) for TD participants*

Measure	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
Cognitive Factors																
1. RPM	-	.45	-.32	-.49	-.41	.53	.51	.64	-.16	.66	-.77*	.59	.14	-.50	.25	-.20
2. MHVS		-	.26	.11	.45	.69	.43	.64	.33	-.43	.00	.23	.82*	-.07	.41	-.19
Anxiety																
SCAS (Child)																
3. Total			-	.88**	.90**	.31	-.06	.27	.89**	.72	.77*	.02	.29	-.18	-.07	-.43
4. Social Phobia				-	.88**	.23	-.01	.17	.72	.72	.92**	-.31	.32	-.13	.16	-.58
5. Generalised Anxiety Disorder					-	.29	-.02	.21	.74	.54	.84*	-.26	.60	-.04	.05	-.34
SCAS (Parent)																
6. Total						-	.87*	.98**	.58	-.36	-.05	.59	.32	-.51	.41	-.34
7. Social Phobia							-	.87*	.24	-.56	-.26	.47	.12	-.61	.30	-.01
8. Generalised Anxiety Disorder								-	.52	-.36	-.15	.62	.27	-.63	.36	-.38
Behaviour Difficulties																
SDQ:																
9. Total									-	.48	.58	.39	.11	-.21	.00	-.32
10. Conduct Problems										-	.75	-.31	-.18	.06	-.30	-.30
11. Hyperactivity											-	-.49	.28	.24	.11	-.36
12. Peer Problems												-	-.36	-.32	-.08	-.10
Cortisol																
13. Mean Cortisol Score													-	.04	.43	-.32
14. AUC														-	.25	.07
Experience Sampling																
15. Mean anxiety															-	-.68
16. Mean affect																-

* *p<.05* ***p<.01*

AUC= Area under the curve; SCAS= Spence Children's Anxiety Scale; SDQ= Strengths and Difficulties Questionnaire

Relationships between Cognitive Factors and Anxiety

Analyses were also undertaken to examine associations between cognitive factors and anxiety for each group (see Tables 7 and 8). This analysis indicated no significant correlations between measures of nonverbal ability (RPM) and measures of anxiety (SCAS, momentary self-report or cortisol) for participants in either group. Further correlations were also explored for individual anxiety domains within the SCAS. This also yielded no significant correlations.

For ASD participants, no associations were identified between measures of verbal ability (MHVS) and measures of anxiety. However, a positive association was identified between the MHVS and mean cortisol levels for TD participants (r= .82, p<.05), indicating that children who scored higher in measures of verbal ability demonstrated higher levels of cortisol across the school day. No further correlations were identified between the MHVS and individual anxiety domains for either group.

Relationships between Cognitive Factors and Behaviour Difficulties

No significant correlations were identified between either the RPM or the MHVS for total scores on the SDQ (see Tables 7 and 8). However, for ASD participants, a positive correlation was identified between the RPM and the peer problems domain (r= .91, p<.01) indicating that as standard scores in the RPM increase as does peer problems in this group. For TD participants a negative association was also identified between the RPM and the hyperactivity domain (r= -.77, p<.05) indicating that as scores on the RPM increase hyperactivity scores decrease. No significant differences were identified between the MHVS and any subscale for participants in either group.

Discussion

The aim of this paper was to explore the relationship between cognitive and language ability factors and anxiety in adolescents with ASD, by comparing parent and child reported anxiety with measures of verbal and nonverbal ability (Mill Hill Vocabulary Scale and Ravens Progressive Matrices). Moreover, to address issues of measurement and assessment a multi-modal assessment technique was employed to more accurately triangulate anxiety and its physiological experience across the school day in a group of

mainstream pupils with ASD. This technique incorporated questionnaire measures, experience sampling and the concurrent collection of salivary cortisol. With the addition of a control group of TD adolescents, this study also allowed for the exploration of differences in anxiety between groups.

Following previous research it was predicted that adolescents with ASD would experience higher levels of physiological arousal across the school day and would demonstrate increased reactivity to social pressures (i.e large group activities). It was anticipated that correlations between this physiological arousal and existing anxiety measures or experience sampling would be higher for TD adolescents than adolescents with ASD. In line with previous research it was also hypothesised that children with ASD would receive higher total anxiety scores than their TD peers and would score higher for social worries. Moreover, anxiety scores (including social phobia and generalised anxiety disorder) were expected to increase with cognitive ability factors for adolescents with ASD while behaviour difficulties were expected to decrease with increasing verbal ability.

The findings of the current study were not consistent with previous research which has found that cognitive factors such as IQ or verbal ability may be associated with anxiety within this population (Hallett et al. 2013; Mayes et al. 2011; Estes et al. 2007; Niditch et al. 2012; Rieske et al. 2013). These findings therefore provide further evidence to suggest that any relationships between cognitive ability or language factors and anxiety do not hold true for children within the normal range of intellectual functioning (i.e within one standard deviation of the mean).

The present study also found no significant differences between groups in either child or parent versions of the SCAS indicating that ASD participants scored no higher in measures of anxiety than their TD peers. This is in contrast with previous research which indicates that prevalence rates of anxiety in individuals with ASD exceed those of the TD population (White et al. 2009; Macneil, Lopes & Minnes, 2009; van Steensel et al. 2011). However, while no significant differences were observed between groups for total anxiety scores, a higher proportion of ASD participants demonstrated elevated anxiety scores. Moreover, further exploration indicated that ASD participants were rated as higher by parents for social phobia, generalised anxiety disorder and obsessive compulsive disorder than TD peers. Participants with ASD also received significantly

higher scores in the SDQ indicating that this group demonstrated more behaviour difficulties including conduct problems, hyperactivity/inattention, peer relationship problems and emotional symptoms.

In line with previous research, parent-child agreement between anxiety measures was found to be weak for both groups. This provides further evidence for the assertion that informant ratings of social, emotional and behavioural problems are often discrepant (De Los Reyes & Kazdin, 2005) and has implications for our understanding of the assessment of such difficulties. Moreover, while parent-child agreement was weak for all participants, a different relationship was observed between groups, whereby TD adolescents rated themselves as more anxious than their parents did, while the opposite association was found for adolescents with ASD. This finding can yield several interpretations. First, it is possible that adolescents with ASD express their feelings of anxiety in ways that are more observable to their parents, while for TD adolescents these feelings may be more likely to remain private, or second, children with ASD may be less able to recognise these feelings of anxiety than their peers. Either way, these interpretations could be used to help explain some of the variance in the assessment of anxiety for children or young people with ASD.

Although no significant differences were observed between groups for either questionnaire measures of anxiety, the results from experience sampling indicated that adolescents with ASD rated themselves as significantly more anxious and lower in positive affect than their TD peers across the school day when asked to comment on their present emotional state. This is interesting as it could indicate that adolescents with ASD find it easier to reflect on their immediate emotional state and may instead find it more difficult to accurately respond to questionnaire measures as they are too detached from actual experience. However, despite these differences, no differences were observed between groups in mean cortisol scores across the study. This therefore suggests that individuals with ASD may experience the same physiological arousal in response to everyday stressors as their TD peers, but may experience more difficulty reporting on these feelings accurately regardless of how this is recorded. This finding is perhaps not surprising as difficulties with emotional awareness have been recognised as a characteristic feature of autism (Hill, Berthoz & Frith, 2004); however this will inevitably have implications on the accurate assessment of anxiety in this population. It is however interesting, and positive that there were no differences between groups in

reported social status. This indicates that adolescents with ASD engaged in similar levels of social activity to their peers.

Interestingly, there were few correlations identified between experience sampled data for both groups. Negative correlations were identified between anxiety and mood (happiness) for both groups, which indicates that individuals were happiest when they were feeling the least anxious. Also, for TD participants positive associations were identified between mood and activity indicating that this group were happiest in larger social groups and during structured times. However, no such relationships were found for adolescents with ASD. Surprisingly, cortisol was not found to correlate with either anxiety or mood. This could therefore highlight a potential weakness with measurement, for example the collection technique may not be sufficiently sensitive or there may have been a delay between collection of experience sampled data and saliva collection. In some samples there may have also been insufficient quantities of saliva provided for accurate analysis. It is also possible that the experimental procedure may have itself increased anxiety leading to discrepancies in recording. It is therefore important that in future research due care is given to ensure that participants are sufficiently briefed to minimise any potential concerns and to improve the consistency of data collection. However, further research is necessary with larger sample sizes before any firm conclusions can be drawn.

Nevertheless, the finding that overall cortisol levels did not differ between groups contrasts with previous research which has demonstrated elevated cortisol responses in children and adolescents with ASD (Corbett et al. 2006). It therefore seems possible that other factors may have contributed to this observation, for example children with ASD may be more likely to avoid stressful situations. It is also possible that this experimental paradigm contributed to an increased level of stress or anxiety for all participants. Further research would therefore be necessary before any firm conclusions can be drawn.

While no differences were observed between groups for mean cortisol scores, different patterns of cortisol variation were found. More specifically, differences were found between groups indicating that adolescents with ASD experienced significantly higher peak cortisol levels than TD adolescents indicating a higher level of physiological arousal in response to environmental stressors. However, it was also

observed that, while TD adolescents demonstrated an expected overall decrease in cortisol levels across the school day, for ASD participants, the opposite variation was observed, whereby cortisol levels actually increased across the school day. This finding is concerning as it is in contrast to the accepted model of the cortisol awakening response (Wust et al. 2000). It could therefore further highlight some methodical weakness inherent in the study; therefore some findings may need to be treated with caution.

To address previous criticisms of assessment and to explore the reliability and consistency of measures, correlations were examined between cortisol levels (both mean scores and AUC) and measures of anxiety, affect and behaviour difficulty. This analysis indicated that cortisol (AUC) was positively associated with increased conduct problems for adolescents with ASD, but not their TD peers. However, no correlations were observed between cortisol and measures of anxiety for either group. Interestingly however, one positive association was identified between cortisol (AUC) and mean experience sampled positive affect for adolescents with ASD. These findings are surprising as they indicate that increased physiological arousal in participants was not associated with higher reported anxiety (either experience sampled or as rated by questionnaires). Again, this could highlight a potential limitation inherent within the methodology as previously discussed.

Despite this criticism, it is interesting that a positive association was observed between mean cortisol scores and positive affect for adolescents with ASD. This indicates that these children reported themselves as happier when they were experiencing elevated physiological arousal. This therefore suggests that for children with ASD the experience and interpretation of emotional arousal may be different than it is for their TD peers. This could potentially provide further evidence for the decoupling of physiological arousal (first-order experience) and its conscious representation (second-order experience) (Lambie & Marcell, 2002), by highlighting different interpretations of the same underlying experience in both groups.

With the exception of one positive correlation between the child version of the SCAS (anxiety questionnaire) and mean experience sampled anxiety for adolescents with ASD, no further correlations were observed between anxiety questionnaire measures' total scores or experience sampled anxiety and affect for either group, indicating weak

agreement between measures and again questioning the validity of such instruments for the assessment of anxiety in ASD. A positive association however, was identified between measures of behaviour difficulty (SDQ) and child-rated anxiety (SCAS) for TD participants. This could suggest that while TD adolescents who experience behaviour difficulties may experience some associated anxiety, adolescents with ASD may be less likely to make this attribution or may be less aware of how these difficulties may affect them.

Associations between Cognitive Factors and Anxiety

Previous research has observed a positive association between cognitive ability factors and anxiety in children with ASD across a broad range of developmental levels (Hallett et al. 2013; Mayes et al. 2011; Estes et al. 2007; Niditch et al. 2012). However studies which solely include higher-functioning participants have failed to find such relationships (Strang et al 2012; Eussen et al. 2013). The present study therefore aimed to explore whether cognitive ability factors were associated with anxiety in a group of adolescents within the "normal range" for intellectual functioning.

In the present study no correlations were observed between measures of nonverbal ability (RPM) and measures of anxiety (including total anxiety scores and cortisol) for either adolescents with ASD or their TD peers. This provides further evidence to support the assertion that any observed relationships between cognitive ability factors and anxiety only hold true for children with IQ scores below average levels (Eussen et al. 2013). Similarly, while a positive association was identified between verbal ability and overall cortisol levels for TD participants, no relationships were observed between verbal ability measures (MHVS) and anxiety in adolescents with ASD.

These findings therefore raise the question as to why cognitive ability factors are not associated with anxiety in children within the normal range for intellectual functioning. One simple explanation is that for adolescents in this group, there was insufficient variation in ability scores to detect changes. It is also possible that the participants included in this study showed below average symptom severity or anxiety evidenced by their inclusion in a typical mainstream setting. However, these explanations are likely to be over-simplistic. Researchers have previously explained the association between cognitive ability and anxiety through an increased understanding or awareness of their individual difficulties and social pressures combined with a lack of capacity to self-

regulate or change their behaviour (Niditch et al. 2012). Moreover, it has been suggested that children with ASD who are more increasingly able are likely to demonstrate an increasing capacity to worry. This idea mirrors the developmental patterns of fears and worries in TD children (Muris, Merckelbach & Luitjen, 2002). It therefore seems possible that cognitive ability factors only interact with anxiety in less able children by reducing their capacity to worry as opposed to increasing the capacity in those who are more able.

Associations between Cognitive Factors and Behaviour Difficulties

Previous research has suggested that increased behaviour difficulties such as challenging behaviour, aggression and hyperactivity are often associated with learning and communication difficulties in childhood and adolescence (Clark, Prior & Kinsella, 2002). Moreover, it has been suggested that externalising behaviours and behaviour difficulties are often higher in less able children as these individuals can lack the appropriate skills to express their thoughts, feelings and emotions in more socially accepted ways. It was therefore predicted that behaviour difficulties (as measured by the SDQ) would correlate negatively with measures of verbal and nonverbal ability. However, in the present study, with the exception of one negative association between nonverbal ability and the hyperactivity scale of the SDQ for TD participants, no other expected associations were observed between either measure of cognitive ability and behaviour difficulties.

Furthermore, one positive correlation was identified between nonverbal ability and the peer problems domain for adolescents. While this finding contrasts with previous research, it is possible that all adolescents with ASD may experience some difficulties with peer relationships due to the inherent social difficulties of the disorder; however those who are more cognitively able may be more likely to be included in activities with their peers and therefore a greater number of difficulties. Again, further research may be needed before any firm conclusions can be drawn.

Conclusion, limitations and directions for future research

In summary, the present study found no evidence for associations between cognitive ability factors and anxiety in this high-functioning sample of adolescents with ASD. While this is in contrast with previous research, these findings are in line with Strang et

al. (2012) and Eussen et al. (2013) who suggested that any associations observed between these factors in previous studies only hold true for children with below average intellectual levels. In contrast to previous studies, adolescents with ASD were not found to have higher total anxiety scores than their TD peers. However, as expected, ASD participants received higher anxiety scores for social phobia than controls.

The present study helps to shed light on anxiety and its physiological experience for adolescents with ASD. More specifically, the present study provides evidence to suggest that adolescents with ASD experience similar absolute levels of cortisol to their TD peers across the school day. In other words all participants experienced similar levels of physiological arousal in response to the everyday social and environmental stressors experienced across a school day (although the precise patterns of variation differed between groups).

However, while no differences were observed between overall cortisol levels, the findings from experience sampling indicate that adolescents with ASD still rated themselves as significantly more anxious and lower in positive affect. This means that adolescents with ASD may interpret similar bodily cues in different ways to their TD peers. This provides support for Lambie and Marcel's (2002) model of emotional awareness and could inform models of support.

This study also further highlights potential difficulties for the assessment of anxiety within ASD populations. Poor agreement existed between anxiety scales and it is also unclear how these measures related to the underlying physiological arousal experienced by that individual. In particular, the findings from experience sampling suggest that children with ASD may experience difficulties accurately reporting on their internal experience. Further research is therefore necessary to improve our understanding of the assessment of anxiety in individuals with ASD.

In addition to these concerns, there are a number of further limitations that need to be considered and may need to be overcome in future research. For example, it needs to be noted that the MHVS only provides a measure of vocabulary and not a measure of verbal IQ. This could have implications on the reliability of the current findings, however its use in the present study was justified for practical reasons as this measure provides a quick and efficient screen and acts as a proxy for verbal IQ. It has also been shown to correlate with existing measures of intelligence and verbal ability (Court &

Raven, 1995; Raven, 2000). The present study also included a relatively small sample size of only 16 participants. Larger sample sizes would help improve the validity and reliability of further findings. Furthermore, while steps were taken to match control participants (TD adolescents), group differences revealed significantly lower ability scores in the TD group, with one participant's ability score placing them in the below average range for nonverbal ability. Adherence was generally good (91%), however one TD participant dropped out after one day of data collection.

Although this study did not observe any relationships between cognitive ability factors and anxiety in this sample, evidence was found to suggest that more able adolescents with ASD are likely to experience more general or social worries than their TD peers. This therefore helps to identify children who may be at risk for developing anxiety. Future research would be helpful to further explore these worries in more detail. It would also be interesting to explore differences in cortisol variations across the day in more detail and how this relates to specific environmental or social stressors.

The present study has useful implications for our understanding of anxiety and its assessment in adolescents with ASD. In particular it helps to shed light onto the physiological experience of anxiety and suggests that individuals with ASD may find it difficult to accurately and objectively express their internal emotional experience to others. This could suggest that existing questionnaire measures of anxiety may be inappropriate as they are too detached from direct experience and could inform the development of alternative measures. These findings can also inform the future practice of Educational Psychologists, for example by helping to identify individuals who may be at risk of developing anxiety it becomes possible to develop proactive, preventative intervention. Such intervention would require appropriate and accessible models for developing emotional awareness and emotional literacy skills. This research also highlights the need to consider appropriate methods to support children who may otherwise find it difficult to express their feelings of negative affect. Moreover, this study began to explore what type of activities or situations may be more challenging for individuals with ASD. Again, this could help to inform the practice of ASD-friendly approaches within schools by encouraging reflection on the individual's experience of the school day. To this end, the experience sampling technique could provide a valuable tool for the future research of practitioner psychologists. The use of cortisol measures as a physiological indicator of anxiety also helped to develop our

understanding of anxiety in this population. However additional research is necessary before any firm conclusions can be drawn.

Appendix A. Spence Children's Anxiety Scale- Child Version (SCAS-C) (Spence, 1998)

SPENCE CHILDREN'S ANXIETY SCALE

Your Name: _____ **Date:** _____

PLEASE PUT A CIRCLE AROUND THE WORD THAT SHOWS HOW OFTEN EACH OF THESE THINGS HAPPEN TO YOU. THERE ARE NO RIGHT OR WRONG ANSWERS.

1.	I worry about things	Never	Sometimes	Often	Always
2.	I am scared of the dark	Never	Sometimes	Often	Always
3.	When I have a problem, I get a funny feeling in my stomach	Never	Sometimes	Often	Always
4.	I feel afraid	Never	Sometimes	Often	Always
5.	I would feel afraid of being on my own at home	Never	Sometimes	Often	Always
6.	I feel scared when I have to take a test	Never	Sometimes	Often	Always
7.	I feel afraid if I have to use public toilets or bathrooms	Never	Sometimes	Often	Always
8.	I worry about being away from my parents	Never	Sometimes	Often	Always
9.	I feel afraid that I will make a fool of myself in front of people	Never	Sometimes	Often	Always
10.	I worry that I will do badly at my school work	Never	Sometimes	Often	Always
11.	I am popular amongst other kids my own age	Never	Sometimes	Often	Always
12.	I worry that something awful will happen to someone in my family	Never	Sometimes	Often	Always
13.	I suddenly feel as if I can't breathe when there is no reason for this	Never	Sometimes	Often	Always
14.	I have to keep checking that I have done things right (like the switch is off, or the door is locked)	Never	Sometimes	Often	Always
15.	I feel scared if I have to sleep on my own	Never	Sometimes	Often	Always
16.	I have trouble going to school in the mornings because I feel nervous or afraid	Never	Sometimes	Often	Always
17.	I am good at sports	Never	Sometimes	Often	Always
18.	I am scared of dogs	Never	Sometimes	Often	Always
19.	I can't seem to get bad or silly thoughts out of my head	Never	Sometimes	Often	Always
20.	When I have a problem, my heart beats really fast	Never	Sometimes	Often	Always
21.	I suddenly start to tremble or shake when there is no reason for this	Never	Sometimes	Often	Always
22.	I worry that something bad will happen to me	Never	Sometimes	Often	Always
23.	I am scared of going to the doctors or dentists	Never	Sometimes	Often	Always
24.	When I have a problem, I feel shaky	Never	Sometimes	Often	Always
25.	I am scared of being in high places or lifts (elevators)	Never	Sometimes	Often	Always

26.	I am a good person.....	Never	Sometimes	Often	Always
27.	I have to think of special thoughts to stop bad things from happening (like numbers or words).....	Never	Sometimes	Often	Always
28	I feel scared if I have to travel in the car, or on a Bus or a train.....	Never	Sometimes	Often	Always
29.	I worry what other people think of me.....	Never	Sometimes	Often	Always
30.	I am afraid of being in crowded places (like shopping centres, the movies, buses, busy playgrounds).....	Never	Sometimes	Often	Always
31.	I feel happy.....	Never	Sometimes	Often	Always
32.	All of a sudden I feel really scared for no reason at all.....	Never	Sometimes	Often	Always
33.	I am scared of insects or spiders.....	Never	Sometimes	Often	Always
34.	I suddenly become dizzy or faint when there is no reason for this.....	Never	Sometimes	Often	Always
35.	I feel afraid if I have to talk in front of my class.....	Never	Sometimes	Often	Always
36.	My heart suddenly starts to beat too quickly for no reason.....	Never	Sometimes	Often	Always
37.	I worry that I will suddenly get a scared feeling when there is nothing to be afraid of.....	Never	Sometimes	Often	Always
38.	I like myself.....	Never	Sometimes	Often	Always
39.	I am afraid of being in small closed places, like tunnels or small rooms.	Never	Sometimes	Often	Always
40.	I have to do some things over and over again (like washing my hands, cleaning or putting things in a certain order).....	Never	Sometimes	Often	Always
41.	I get bothered by bad or silly thoughts or pictures in my mind.....	Never	Sometimes	Often	Always
42.	I have to do some things in just the right way to stop bad things happening.....	Never	Sometimes	Often	Always
43.	I am proud of my school work.....	Never	Sometimes	Often	Always
44.	I would feel scared if I had to stay away from home overnight.....	Never	Sometimes	Often	Always
45.	Is there something else that you are really afraid of?.....	YES	NO		
	Please write down what it is_____				
	_____				
	_____				
	How often are you afraid of this thing?.....	Never	Sometimes	Often	Always

Appendix B. Spence Children's Anxiety Scale- Parent Version (SCAS-P) (Spence, 1998)

SPENCE CHILDREN'S ANXIETY SCALE
(Parent Report)

Your Name: _____ **Date:** _____

Your Child's Name: _____

BELOW IS A LIST OF ITEMS THAT DESCRIBE CHILDREN. FOR EACH ITEM PLEASE CIRCLE THE RESPONSE THAT BEST DESCRIBES YOUR CHILD. PLEASE ANSWER ALL THE ITEMS.

1.	My child worries about things	Never	Sometimes	Often	Always
2.	My child is scared of the dark	Never	Sometimes	Often	Always
3.	When my child has a problem, s(he) complains of having a funny feeling in his / her stomach	Never	Sometimes	Often	Always
4.	My child complains of feeling afraid	Never	Sometimes	Often	Always
5.	My child would feel afraid of being on his/her own at home	Never	Sometimes	Often	Always
6.	My child is scared when s(he) has to take a test	Never	Sometimes	Often	Always
7.	My child is afraid when (s)he has to use public toilets or bathrooms	Never	Sometimes	Often	Always
8.	My child worries about being away from us / me	Never	Sometimes	Often	Always
9.	My child feels afraid that (s)he will make a fool of him/herself in front of people	Never	Sometimes	Often	Always
10.	My child worries that (s)he will do badly at school	Never	Sometimes	Often	Always
11.	My child worries that something awful will happen to someone in our family	Never	Sometimes	Often	Always
12.	My child complains of suddenly feeling as if (s)he can't breathe when there is no reason for this	Never	Sometimes	Often	Always
13.	My child has to keep checking that (s)he has done things right (like the switch is off, or the door is locked)	Never	Sometimes	Often	Always
14.	My child is scared if (s)he has to sleep on his/her own	Never	Sometimes	Often	Always
15.	My child has trouble going to school in the mornings because (s)he feels nervous or afraid	Never	Sometimes	Often	Always
16.	My child is scared of dogs	Never	Sometimes	Often	Always
17.	My child can't seem to get bad or silly thoughts out of his / her head	Never	Sometimes	Often	Always
18.	When my child has a problem, s(he) complains of his/her heart beating really fast	Never	Sometimes	Often	Always

19.	My child suddenly starts to tremble or shake when there is no reason for this	Never	Sometimes	Often	Always
20.	My child worries that something bad will happen to him/her	Never	Sometimes	Often	Always
21.	My child is scared of going to the doctor or dentist	Never	Sometimes	Often	Always
22.	When my child has a problem, (s)he feels shaky	Never	Sometimes	Often	Always
23.	My child is scared of heights (eg. being at the top of a cliff)	Never	Sometimes	Often	Always
24.	My child has to think special thoughts (like numbers or words) to stop bad things from happening	Never	Sometimes	Often	Always
25.	My child feels scared if (s)he has to travel in the car, or on a bus or train	Never	Sometimes	Often	Always
26.	My child worries what other people think of him/her	Never	Sometimes	Often	Always
27.	My child is afraid of being in crowded places (like shopping centres, the movies, buses, busy playgrounds)	Never	Sometimes	Often	Always
28	All of a sudden my child feels really scared for no reason at all	Never	Sometimes	Often	Always
29.	My child is scared of insects or spiders	Never	Sometimes	Often	Always
30.	My child complains of suddenly becoming dizzy or faint when there is no reason for this	Never	Sometimes	Often	Always
31.	My child feels afraid when (s)he has to talk in front of the class	Never	Sometimes	Often	Always
32.	My child's complains of his / her heart suddenly starting to beat too quickly for no reason	Never	Sometimes	Often	Always
33.	My child worries that (s)he will suddenly get a scared feeling when there is nothing to be afraid of	Never	Sometimes	Often	Always
34.	My child is afraid of being in small closed places, like tunnels or small rooms	Never	Sometimes	Often	Always
35.	My child has to do some things over and over again (like washing his / her hands, cleaning or putting things in a certain order)	Never	Sometimes	Often	Always
36.	My child gets bothered by bad or silly thoughts or pictures in his/her head	Never	Sometimes	Often	Always
37.	My child has to do certain things in just the right way to stop bad things from happening	Never	Sometimes	Often	Always
38.	My child would feel scared if (s)he had to stay away from home overnight	Never	Sometimes	Often	Always
39.	Is there anything else that your child is really afraid of?	YES	NO		
	Please write down what it is, and fill out how often (s)he is afraid of this thing: _____	Never	Sometimes	Often	Always
	_____	Never	Sometimes	Often	Always
	_____	Never	Sometimes	Often	Always

Appendix C. Strengths and Difficulties Questionnaire (SDQ) (Goodman, 1997)

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.

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

Date of Birth.....

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

Appendix D. Ethical approval

UNIVERSITY OF Southampton

This is to confirm the University of Southampton is prepared to act as 'Research Sponsor' for this study, and the work detailed in the protocol/study outline will be covered by the University of Southampton insurance programme.

As the Sponsor's representative for the University this office is tasked with:

1. Ensuring the researcher has obtained the necessary approvals for the study

2. Monitoring the conduct of the study

3. Registering and resolving any complaints arising from the study

As the Chief/Principle Investigator you are responsible for the conduct of the study and you are expected to:

1. Ensure the study is conducted as described in the protocol/study outline approved by this office

2. Advise this office of any change to the protocol, methodology, study documents, research team, participant numbers or start/end date of the study

3. Report to this office as soon as possible any concern, complaint or adverse event arising from the study

Failure to do any of the above may invalidate your ethics approval and therefore the insurance agreement, affect funding and/or sponsorship of your study; your study may need to be suspended and disciplinary proceedings may ensue.

On receipt of this letter you may commence your research but please be aware other approvals may be required by the host organisation if your research takes place outside the University. It is your responsibility to check with the host organisation and obtain the appropriate approvals before recruitment is underway in that location.

May I take this opportunity to wish you every success for your research

Submission ID : 6663

Submission Name: An exploration into anxiety and the physiological experience for children with Autism Spectrum Disorder (ASD)

Date : 26 Jul 2013

Created by : Matthew Brown

Appendix E. Parent Information Letter

Parent or Guardian
Home or School address

<Date>

Dear Parent or Guardian

Invitation to take part in a research project: An exploration into anxiety and the physiological experience for children with Autism Spectrum Disorder (ASD)

Researcher: Matthew Brown **Ethics number**: 6663

We would like to invite your child to take part in a research study. Before you decide, you need to understand why the research is being done and what it would involve for your child. Please take time to read the following information carefully. Ask us if there is anything that is not clear or if you would like more information. If you are happy to participate you will be asked to sign a consent form.

What is the research about?

This project is being carried out by a trainee educational psychologist as part of their doctoral training and is funded by the University of Southampton.

The aim of this research is to explore physiological differences in anxiety in children with ASD when compared to their peers. The project has three main aims: (1) To explore what anxiety looks like across the school day for children with ASD; (2) to examine differences in anxiety between children with ASD and their TD peers, and (3) to compare the self-reported experience of anxiety with physiological experience.

We hope that this project will help us to understand whether children with ASD experience anxiety differently to their peers, and what sort of things make them worried or concerned. It will also allow us to identify any differences between self-reported worries or concerns and physiological arousal. This information should help develop our understanding of anxiety in ASD and could be used to help support children in schools.

Why has my child been chosen?

Your child has been chosen to participate due to their attendance within a mainstream resourced provision.

What will happen if my child takes part?

If you choose to take part your child will first be asked to complete three questionnaires and complete a 30-60 minute screening activity. The project will then take place within school hours for three days. For the duration of the study your child will be given access to a palm-pilot. This will prompt them at random intervals to answer several questions about their mood. They will also be asked to provide a sample of cortisol (which is found in saliva). This will involve chewing on a dental roll for 30 seconds.

Are there any benefits in my taking part?

Upon completion of this project, Matthew Brown (trainee educational psychologist) will feedback findings and implications to school staff. Schools will also receive additional input surrounding anxiety to help develop expertise and confidence when working with children with ASD.

Are there any risks involved?

We do not envisage any risk in this research. However your child may experience some disruption to lessons or may feel uncomfortable providing saliva samples in public. Support staff will be available for reassurance. You will also be able to discuss any concerns with these staff or the researcher.

Will my child's participation be confidential?

Anonymity cannot be confirmed as participants will be using palm pilots during the school day, however all data shall remain confidential. Once collected, data will be coded and all names removed. This information will then be stored in a locked cabinet or a password protected computer in accordance with the Data Protection Act.

What happens if I change my mind?

You are free to withdraw from the research at any time, without providing an explanation.

What happens if something goes wrong?

In the unlikely case of concern or complaint, please contact:

Chair of the Ethics Committee, Psychology,
University of Southampton
Southampton

SO17 1BJ.

Phone: +44 (0)23 8059 4663, email slb1n10@soton.ac.uk

Where can I get more information?

If you would like any more information please feel free to get in contact:

Matthew Brown (Trainee Educational Psychologist): mb29g11@soton.ac.uk

Appendix F. Young Person Information Sheet

Exploring Anxiety across the School Day

We are asking if you would like to take part in a research project to help us understand what sorts of things make young people worried or concerned in school and how different people might experience this in different ways. Before you decide if you want to take part, it is important that you understand why the research is being done and what it will involve for you. So please read and think about this information carefully. If you want to, you can talk about it with your family and friends.

Why are we doing this research?

We are doing this research to help us find out more about what worries and concerns children may have at school, and how different children experience these feelings in different ways.

Why have I been invited to take part?

We are inviting all young people aged between 11 and 16 from your classes to take part.

Do I have to take part?

No, it is up to you. Before you make this decision, you can ask the researcher to answer any questions that you might have. We have already sent an information sheet to your parent or guardian. And they have told us that they are happy for you to take part. But the final decision is up to you. If you think you might want to take part you can fill out the form at the end of this information sheet. You will be given a copy of this information sheet to keep. If you agree to take part, you can stop at any time, without giving a reason.

What will happen to me if I take part?

If you decide to take part, then we will first ask you to complete some questionnaires about how you think and feel and to complete some puzzles of varying difficulty. In addition we will also ask a teacher to complete a questionnaire about what sorts of things might worry you in school. To measure how you feel in school you will be given a handheld device for three days. This device will prompt you at random times during the school day to answer some questions about how you are feeling and what things you are doing. To measure how your body is responding to these feelings you will also be asked to provide a sample of saliva. This will be collected by chewing on a piece of material for 20-30 seconds.

What are the benefits of taking part?

We hope that this project will help us better understand how different children experience anxiety, worries and concerns in different ways. This information should help us to develop new ways of helping other children who may feel anxious or worried in school.

What happens when the study is finished?

When the study is finished we will look at all the information we have gathered. We will send you and your school a summary of what we have found and will outline how this might be useful for you. Sometimes, once we have finished a project we will publish this information so other researchers can find out about what we have been doing and what we found. But we will never publish your name or any other information that will let people know who you are.

What if there's a problem or something goes wrong?

There are very few risks involved in taking part in this study and it is unlikely that there will be a problem. If you are worried about anything and you decide you want to stop that's OK.

Who is organising and funding the research?

This project is being carried out by a trainee from the University of Southampton and is being funded by the university's research department

Who has reviewed this study?

The study has been reviewed by other people who work at the University of Southampton; this means that they think the project is good and valid. It has also been reviewed by the ethics' committee at the University of Southampton who make sure that the research is fair - they are happy that this research is ethical and safe.

What happens I want to find out more?

If you have any questions you can ask me now, or ask your teacher to speak to me. You can also contact me privately by email (mb29g11@soton.ac.uk) .

What happens if I find some of the questions you ask upsetting?

If you need any advice or help on how you feel about the questionnaires or anything else we ask you to do you can speak to a number of different people. This could be someone you know, like your parent/guardian or your class teacher. If you are still worried or upset, then remember, you do not have to take part.

If you are happy to help us with this study, then answer the questions below and sign your name.

Have you read about this project?	Yes/ No
Has somebody else explained this project to you?	Yes/ No
Do you understand what this project is about?	Yes/ No
Have you asked all the questions you want?	Yes/ No
Have you had your questions answered in a way you understand?	Yes/ No
Do you understand it's OK to stop taking part at any time?	Yes/ No

Are you happy to take part? Yes/ No

If you want to take part, you can write your name below

Your name _____ Date _____

The person who explained this project to you needs to sign too:

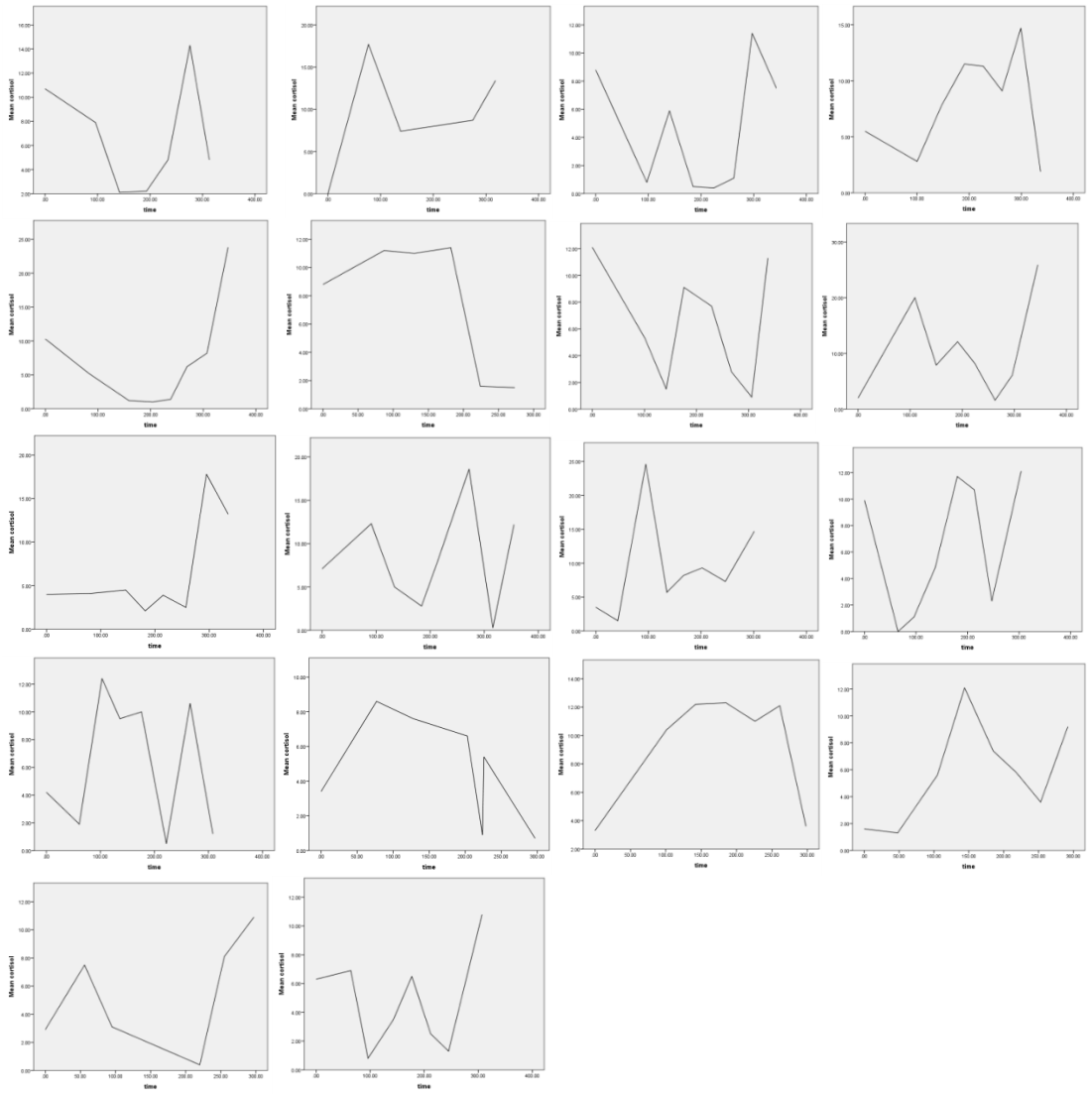
Print Name Researcher name

Sign _____ Date _____

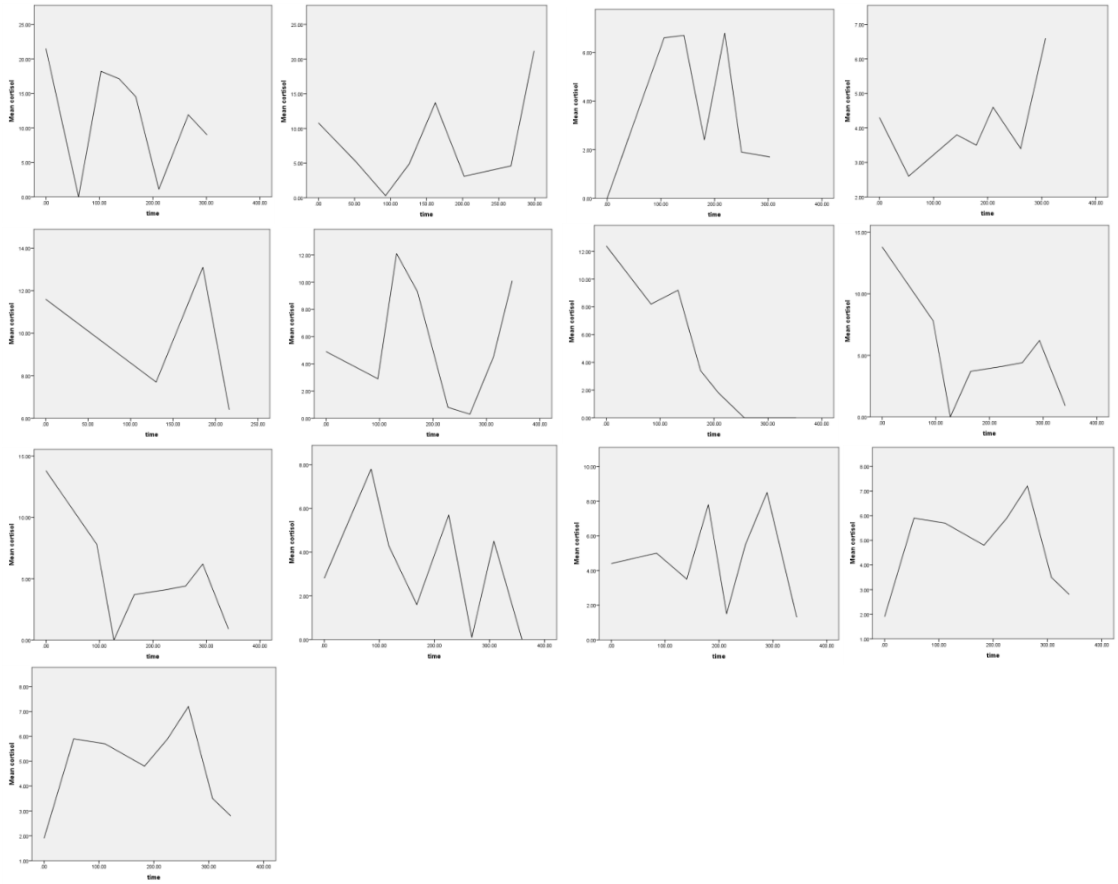
THANK YOU FOR YOUR HELP

Appendix G: Cortisol responses by participants across days

ASD Participants



TD Participants



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