ANXIETY IN AUTISM SPECTRUM DISORDER (ASD):

THE INFLUENCE OF EXECUTIVE AND SENSORY PROCESSING DYSFUNCTIONS

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Declaration

I declare that the thesis entitled ‘Anxiety in Autism Spectrum Disorder (ASD): The Influence of Executive and Sensory Processing Dysfunctions’ is entirely my own work.

The research was carried out from December 2010 to July 2015 at Newcastle University. All activities in this thesis are original unless acknowledged in the text or by reference.

The thesis has not been previously submitted at this university or any other universities.

Abstract

Introduction: Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder associated with difficulties with social communication and the presence of restricted and repetitive behaviours. There is significant heterogeneity of symptom profiles within the disorder. Anxiety is very common in individuals with ASD. Previous research suggests associations between executive function deficits and sensory processing atypicalities and anxiety in ASD, though neither relationship has been explored in detail. ***Aims:*** To examine the putative relationships between anxiety, executive function difficulties and sensory processing atypicalities in children with ASD, taking into account potential heterogeneity within the sample. ***Method:*** Thirty six families with a child with ASD were recruited. The children completed an anxiety questionnaire and standardised assessments of executive function. Parents completed questionnaire about their child's anxiety, sensory processing difficulties and autism severity. 22 parents completed a follow-up study of their child's anxiety, everyday executive function and repetitive behaviours. Correlational analysis and cluster analysis were used to examine the data.

Results: Anxiety scores were high and remained stable over a twenty month period. No significant associations were found between objective measures of executive function difficulties and anxiety, though parent reported child executive difficulties were associated with heightened parent reported child anxiety.High anxiety was associated with sensory processing atypicalities, and higher levels of ASD severity. Importantly, cluster analysis revealed distinct subgroups of children in relation to anxiety, sensory and executive profiles, illustrating heterogeneity within the sample.

Conclusions: The findings supports previous research that anxiety is high in children with ASD and remains high over time and is associated with sensory processing atypicalities. The relationship between executive function and anxiety varied as a function of the source of the data. Cluster analysis illustrates the importance of considering heterogeneity in ASD. Implications for clinical practice and future research are discussed.

Dedications

I dedicate this work to my children,

Farhanah, Najlah, Rayyan and Razzien.

They are my pillars of strength, who have been a constant source of support and encouragement during the challenges of postgraduate studies and life.

I am really grateful for having all of you in my life.

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Chapter 1. Introduction

1.1 The concepts of Executive Functions (EF)

Executive functions are processes that control and regulate thoughts and actions and are frequently associated with the brain's frontal lobes (Miyake et al., 2000). It comprises a wide range of cognitive processes and behavioural competencies which include verbal reasoning, problem-solving, planning, sequencing, the ability to sustain attention, resistance to interference, utilization of feedback, multitasking, cognitive flexibility, and the ability to deal with novelty (Burgess, Veitch, de lacy Costello, & Shallice, 2000; Damasio, 1995). This is regarded as the 'cold' part of EF (Chan et al., 2008). On the other hand, EF also involves "emotional", "belief" or "desires" such as the experience of reward and punishment, regulation of one's own social behaviour, and decision-making involving emotional and personal interpretation (Bechara, Damasio, Damasio, & Lee, 1999; Bechara, Tranel, Damasio, & Damasio, 1996). This is regarded as the 'hot' component of EF (Chan et al., 2008)

Individuals with frontal lobe damage usually perform poorly on the Wisconsin Card Sorting Test ((WCST; Berg, 1948; Grant & Berg, 1948) and exhibit deficits on tasks involving planning, decision making and behaviour regulation (Damisio, 1994). Besides the Wisconsin Card Sorting Test, other measures that usually shows EF impairment are the Tower of Hanoi (Goel & Grafman, 1995) and its variant, Tower of London (Shallice, 1982; Owen et al., 1990). These measures have become primary research tools in studying the organization and roles of EF in brain-damaged patients (Miyake et al., 2000).

Teuber (1972) raised an issue as to whether frontal lobes or the central executive can be considered unitary in the sense that they are reflections of the same underlying mechanism or ability? Following that, Miyake et al. (2000) employed latent variable analysis to examine the unity and diversity of three EF functions; shifting, updating and inhibition among 137 college students. Results showed that the three target EF are moderately correlated but clearly separable. Therefore, it is important to recognize both the unity and diversity of executive functions. It is important also to

administer multiple executive tasks to understand the nature of sparing and impairments in patient's executive functioning.

Findings that EF are not unitary have raised the issue of relationships between different EFs and intelligence. Luciano et al. (2001) found that intelligence and working memory share common genetic variance. Therefore, neuropsychological studies are converge on the conclusion that intelligence is related to EF. However, even though it was found correlated, it is still separable (Miyake et al., 2000). Friedman et al. (2006) found that updating working memory (updating) was highly correlated with intelligence measure, but not inhibiting and shifting.

1.2 The concepts of Sensory Processing (SP)

Sensory processing or synonymously called "sensory integration" is a term that refers to the way the nervous system receives messages from the senses and turns them into appropriate motor and behavioural responses (Karanowitz, 2005).

SP Dysfunctions is a neurological disorder that involves impairment in processing information from different senses, vestibular system and body awareness (Goldstein & Morewitz, 2011). It prevails in children and adult (Kane, 2004). In person with SP dysfunction, the brain may process the sensory input in an irregular way, causing problems with balance and anxiety (Goldstein & Morewitz, 2011). Children with SP dysfunctions may over or under-respond to sensory stimuli or engage in behaviours to stimulate their senses (Miller et al., 2007) which is also known as sensory modulation disorder (SMD). Another aspect of SMD is sensory defensiveness where children with sensory defensiveness over-respond to sensory input and react by displaying negative emotions or behaviours.

As a result, children with SP dysfunctions may have hard time functioning in their daily lives. They may look fine and have superior intelligence but may be awkward and clumsy, fearful and withdrawn or even hostile and aggressive (Karanowitz, 2005). Therefore, SP dysfunctions can affect not only how they move and learn, but also how they behave, how they play and make friends especially how they feel about themselves (*ibid*).

Tomchek and Dunn (2007) investigate differences in sensory processing among age-matched children between ages 3 and 6 years with autism spectrum disorders (ASD) and those who are typically developing. About 95% of the sample of children with ASD demonstrated some degree of sensory processing dysfunction on the Short Sensory Profile total score, with the greatest differences reported on the Underresponsive/Seeks Sensation, Auditory Filtering, and Tactile Sensitivity sections. The ASD group also performed significantly differently ($p < .001$) on 92% of the items, total score, and all sections of the SSP.

Research and clinical assessment of sensory experiences in young children, and especially young children with autism, recognizes that these children are unlikely to be able to respond to self-report measures of their sensory experiences. Thus, clinical assessments with this population often rely on direct observation of the child during natural or test conditions, and/or a parent report format. Parent report instruments are most often used in studies characterizing sensory processing difficulties. One of the most commonly used tools is the caregiver-report assessment, the Sensory Experiences Questionnaire (SEQ; Baranek, 1999), Baranek et al. (2006) examined the the nature of sensory patterns of hyper- and hypo-responsiveness, their prevalence, and developmental correlates in autism relative to comparison groups. They found that SEQ was able to characterize sensory features in young children with autism, and differentiate their sensory patterns from comparison groups. Another commonly used tools for SP is the Short Sensory Profile (SSP; McIntosh, Miller, & Shyu, 1999). The SSP is a 38-item caregiver report measure comprising the items that demonstrated the highest discriminative power of atypical sensory processing among all the items from the long version, the Sensory Profile (SP; Dunn, 1999). The gold standard of standardized assessments for sensory dysfunction is the Sensory Integration and Praxis Test (SIPT; Ayers, 1989). This tool provides a comprehensive assessment of sensory functioning for children ages 4 years to 8 years, 11 months old. The SIPT involves direct observation of a child's behaviour rather than relying on questionnaires.

1.3 Integration of EF and SP

Executive functions have been roughly classified into a “cold” and a “hot” component (Chan et al., 2008). The dorsolateral prefrontal cortex is important in mediating the “cold” one such as mechanistic planning, problem-solving, or verbal reasoning, whereas the ventromedial or orbitofrontal prefrontal cortex mediates the “hot” functions such as interpersonal and social behaviour, and the interpretation of complex emotions during social interaction. Therefore, recent advancement of social cognitive neuroscience paves a platform to link the social behaviours of the brain in terms of these “cold” and “hot” functions in everyday life functioning at a theoretical basis (e.g., Grafman & Litvan,1999).

In addition, each individual manifests differently in terms of the nature of their EF deficits. Miyake and Friedman (2012) found that individual differences in EF as measured with simple laboratory tasks show both unity in diversity, reflect substantial genetic contributions, related to various clinical and societal issues and shows some developmental stability. The author recommended that individual differences in EFs are highly relevant to many different sub disciplines of psychological science and could have broad implications for basic and applied research (*ibid*). In this regard, the author also suggested that it is important to examine the unitary and diversity framework of EF relates to phenomena in psychology such as cognitive control in depression and anxiety.

Following that also, Altamirano, Miyake and Whitmer (2010) tested 98 college students, who differed in ruminative tendencies and dysphoria levels, on two executive-control tasks (goal maintenance and goal shifting). They found that higher ruminative tendencies predicted more errors on the goal-shifting task but fewer errors on the goal-maintenance task; these results demonstrated that ruminative tendencies have both detrimental and beneficial effects. Moreover, although ruminative tendencies and dysphoria levels were moderately correlated which indicates that rumination and dysphoria can have opposing effects on executive control. Overall, these results suggest that depressive rumination reflects a trait associated with more stability (goal maintenance) than flexibility (goal shifting).

SP dysfunctions also are often associated with neurodevelopmental disorders such as Attention Deficit Hyperactive Disorder (ADHD), autism, dyspraxia, dyslexia, speech delays and Tourette syndrome. SP dysfunctions in children with autism spectrum disorders (ASDs) occurs in four psychological domains, namely emotion, memory, sensation-perception, and motor skills. It proposes that in all four domains three levels of processing can be identified: a basic level, an integrative level, and a "logical" or higher-order level. It also notes that in typically developing people, there is evidence that the integrative level is sub-served by sub-regions of the medial prefrontal cortex (Shalom, 2009). The author proposed that the integrative level in all four domains is responsible for common atypicalities in people with ASDs.

1.4 Autism Spectrum Disorder (ASD)

1.4.1 History and background of ASD

The term 'autism' was first coined by Bleuler (1911), when he attempted to designate a category of the thought disorder that is present in schizophrenic syndromes. The word autism was derived from the Greek word "autos" which means "self" (Gilberg & Coleman, 2000), and "-ism", which implies "orientation or state". Therefore, autism could be defined as the condition of someone who is unusually absorbed in him or herself (Reber, 1995). Kanner (1943) coined the term "infantile autism", referring to a disturbance of affective contact. Kanner's two main symptoms "autistic aloneness" and "obsessive desire for sameness" are still important criteria for the diagnosis of Autism Spectrum Disorder (ASD). The term infantile autism also was taken by Margaret Mahler to imply both an assumed normal phase of the development of self-awareness and a type of childhood psychosis (Mahler, 1952).

Nowadays, it is well recognized that autism is a disorder that affects a range of aspects of development, and that the symptoms manifest differently at different ages (Frith, 1989). It is believed that autism is a consequence of neuronal developmental abnormalities in multiple brain areas, affecting many functions (Rapin, 2005).

1.4.2 Diagnostic Criteria

The classic 'autism' as described by Kanner (1943) is no longer a valid description of autism. Nowadays, autism is regarded as a disorder which has a more varied phenotype of social, communication and/or behavioural difficulties. Autism has been recognized as a distinct diagnosis since 1978. The diagnostic criteria are now based on two well documented systems; The American Psychiatric Association's Diagnostic and Statistical manual (DSM) and International Classification of Disease (ICD).

a. Diagnostic and Statistical Manual, version five (DSM-V; American Psychiatric Association, 2013)

The new version of the Diagnostic and Statistical Manual, version five (DSM-V) was released by The American Psychological Association (APA) in May 2013. In this new manual, autism, Asperger's disorders, Pervasive Developmental Disorder (not otherwise specified) and childhood disintegrative disorder have been consolidated within the overarching category of Autism Spectrum Disorder (ASD; APA, 2013). This reflects that the symptoms of these disorders are now seen to represent a continuum from mild to severe, rather than being distinct disorders.

ASD is now conceptualised as a two-domain model of social-communication deficits and restricted and repetitive interests/behaviours (RRB), rather than by the DSM-IV triad of symptoms where communication deficits were separate from social impairments. In addition, although the criteria for DSM-IV Autistic Disorder required a delay in or complete lack of development in expressive language, this requirement has been eliminated in DSM-5.

Changes within symptom domains have also been warranted. DSM-5 includes for the first time unusual sensory responses in the RRB domain to reflect research showing that these behaviours are prevalent in ASD (Ben-sasson , Hen, Fluss, Cermak, Engel-Yeger & Gal, 2009) and are useful in distinguishing ASD from other disorders (Wiggins et al., 2009). One feature of unusual communication, stereotyped language, has been reassigned to the RRB. Other DSM-IV symptoms

have been retained in DSM-5, but their definition has been revised in order to increase specificity.

b. International Classification of Diseases (ICD-10; World Health Organization, 1993)

ICD version 10 classified autism as a Pervasive Developmental Disorder that is manifest before the age of 3 years and is characterized by extremely marked abnormalities in the capacity for reciprocal interaction, communication and language development, development of symbolic play, repetitive and restricted patterns of interests and activities (WHO, 1993). There is now substantial evidence that autism can be reliably diagnosed in children as young as two years.

1.4.3 Clinical Features of ASD

a. Socialization

The central features of ASD have been described as a markedly decreased capacity for reciprocity in social interactions, resulting in extreme egocentricity and a failure to recognize the uniqueness of other human beings (Rutter, 1983; Wing, 1989). Frith (1989) suggested that this failure is due to the lack of development of a "theory of mind" or the ability to "mentalize", which means the child with autism cannot conceive what others think and feel.

Abnormalities in social behaviour believed to first appear during infancy include the absence of eye to eye signalling, the absence of the use of social and emotional gestures, a lack of reciprocity in social relationships, attachment problems, little interest in peer relationships, lack of empathy and little interest in sharing positive emotions such as pride or pleasure with others (Carr, 2006).

b. Language and Communication

Language development in autistic children is usually delayed and characterized by a variety of pragmatic abnormalities, including pronominal reversal, echolalia, neologisms and speech idiosyncrasies (Carr, 2006). Individuals with ASD rarely

engage in extended conversation focusing on social and affective issues and display little creativity in language use. It is also essential to understand that the communication deficit in autism is not to do with spoken language per se, but with a failure to grasp the meaning of communication (Frith, 1989).

Children with ASD are able to learn to follow instruction, but may be unable to understand the meaning of this instruction and make little, if any, use of mime or gestures. They tend to misinterpret the human facial expression (Gilberg & Coleman, 2000). Approximately one in two children fail to develop useful spoken language and this is usually confounded with learning disability (*Ibid*).

c. Imaginative Development

Imaginative skills are often impaired in children with autism and this may contribute to difficulties moving from one thought to another (Wing, 1981). Wing and Gould (1979) found that impaired imagination is linked to repetitive behaviour. Honey, Leekam, Turner and McConachie (2007), found that repetitive behaviours were associated with play in ASD, but not in typical development. However, there was also an association between play, repetitive behaviour and language, confirming the international classification system description of imagination as a component of language and communication difficulties. Research shows that children with autism have specific impairments in spontaneous symbolic play that may extend to functional play (e.g. Williams et al., 2001). In addition, Wolfberg (2009) found that paucity of spontaneous play is a distinguishable feature of autism, one not easily disentangle from cognitive, social and affective aspects of the disorder.

Difficulties with social negotiations or in reciprocity of feelings and ideas also contribute to a lack of sharing in play. Some studies have attempted to explore the deficit in symbolic play by employing tasks designed to measure ability to comprehend “pretence”, or executive function tasks that involve the ability to plan thought systematically. The results suggest that autistic individuals may perform poorly on executive function tasks (Jarrold, Boucher & Smith, 1994). Rutherford and Rogers (2003) examined the cognitive underpinnings of spontaneous and prompted pretend play in 28 young children with autism, 24 children with other developmental

disorders, and 26 typical children. Children with autism were significantly delayed on pretend play scores. They also had significant deficits in our ToM measure, but not on EF measures. Regression analyses found that the EF measure of generativity predicted deficit on pretend play.

d. Repetitive Behaviours

Repetitive behaviour is an umbrella term that refers to a disparate class of behaviours characterized by repetition, rigidity, invariance, and inappropriateness (Turner, 2003). It is widely known to be one of the core features of autism (ICD-10, World Health Organization, 1993; DSM-V, American Psychiatric Association, 2013).

Kanner described repetitive behaviours as “anxiously obsessive desire for sameness" in his paper in 1943. Turner (2003) divides this broad range of behaviour into two categories:

> Lower-level behaviours that are characterised by repetition of movement (dyskinesia, tics, stereotyped movements, repetitive manipulation of objects, and repetitive forms of self-injurious behaviour), and
> More complex or higher-level behaviours (object attachments, insistence on the maintenance of sameness, repetitive speech, and circumscribed interests).

These behaviours are characterized by stereotyped and repetitive patterns within a range of restricted interests that most autistic children display. There is also a strong desire to maintain routines and sameness and a resistance to change. Many children demand that certain routines to be adhered to in a pathologically rigid fashion. They often form bizarre attachments to certain objects or parts of objects. It appears that minor changes tend to be more upset and to cause more severe tantrums than make major changes.

1.4.4 Sensory Processing Deficits in ASD

Abnormal response to sensory stimuli is now recognized as a core feature of ASD (APA, 2013). Abnormal response to sound is the most characteristic of all, followed by atypical reactions to visual stimuli. Children with ASD may also show abnormal sensitivity to pain, heat or cold, fascination with contrasts or part or objects and may have a tendency to smell people and objects (Leekam et al., 2007).

1.5 Psychological Theories of Autism

1.5.1 Theory of Mind

The theory of mind deficit suggests that a deficit in the social brain can contribute to an inability to understand certain basic aspects of communication (Baron-Cohen et al., 2000a). This theory suggests that the social and communicative characteristics of autism are due to an inability to form cognitive representations of other's mental states. In other words difficulty understanding other minds is a core cognitive feature of ASD.

Normally, at the age of 3 to 4 years old, children already know that the brain has a set of mental functions, such as dreaming, wanting, thinking, and keeping secrets. Children with autism have been consistently reported to appear to know about physical functions, but typically fail to mention any mental function of the brain, such as difficulties both in the production of deception and in understanding when someone else is deceiving them (Baron-Cohen et al., 2000b). This deficit has been reported even in the highest functioning individuals with ASD (*ibid*).

1.5.2 Weak Central Coherence (WCC)/Attention to detail (ATD)

The Weak Central Coherence (WCC) hypothesis, originally proposed by Frith (1989) suggests that unlike neurotypical individuals, people with autism has difficulty to make sense of the global features of a situation and that they have a tendency to process information piecemeal rather than in context, taking a bottom-up rather than top-down approach to managing informational input (Happe & Frith, 1996). According to Happe (1999), in the case of strong central coherence this tendency would work at the expense of attention to and memory for details.

In the case of weak central coherence this tendency would favour piecemeal processing at the expense of contextual meaning.

Good performance on tests such as the Embedded Figures test or Block Design Test of the WISC has been viewed as a sign of weak central coherence in individuals with autism (Shah & Frith, 1983).

Alternative accounts of WCC/ATD in ASD have been proposed which acknowledge atypical ATD in ASD groups but offer different explanations to impaired global processing. For example, Pellicano and Burr (2012) proposed a Bayesian model of ASD perception. This model suggest that individuals with ASD rely less on prior knowledge when perceiving the world. Therefore, they see a more accurate or detailed representation of the world and their perceptions are less influenced by or generalised towards a 'probable' interpretation (Pellicano & Burr, 2012).

1.5.3 Executive Dysfunction

Executive functioning refers to the higher-order cognitive processes such as response initiation and selection, planning and strategy formation, cognitive flexibility, and inhibition of a prepotent response (e.g. Stuss & Knight, 2002). These processes are typically affected following alterations in prefrontal cortex functioning arising through acquired abnormalities such as tumours, infections and brain injury. However, impairments in executive functioning are also exhibited in neurodevelopmental disorders that are associated with frontostriatal dysfunction, including autism spectrum disorders. Executive functioning deficits have been established as part of the neuropsychological profile of ASD (e.g. Hill, 2004).

Studies in executive functioning in ASD have identified problems in verbal fluency (e.g. Ambery et al., 2006; Turner, 1999) and cognitive flexibility in children and in adults (e.g. Lopez et al., 2005). However, there are also studies which have not replicated executive deficits in ASD. For example, several studies do not report verbal fluency deficits (e.g. Russell et al., 2003) although Lopez et al. (2005) did find a marked perseveration difficulty. Other studies have also not replicated the findings of cognitive flexibility impairments (e.g. Russell, 2002).

1.6. Neurobiological Underpinnings of Executive and Sensory Processing Dysfunctions

1.6.1 Brain abnormalities of Autism

The heterogeneity of clinical features of autism causes difficulties for researchers in identifying specific anatomical abnormalities in the brain. A number of differences in brain structure and function in autistic people have been identified. There are three possible causal models for these abnormalities and the models are not mutually exclusive:

a. Genetic or environmental factors, or genetic factors in the presence of an environmental trigger, may have led directly to abnormal development of the neural substrate from which the brain area in question arose.

b. The area may have been damaged following a period of normal development, by hypoxia at birth for example.

c. The informational input into a particular brain structure may be deficient, leading to abnormalities arising as an outcome of the developmental process.

The first two 'lesion-deficit' models (Thomas & Karmiloff-Smith, 2002) attribute abnormalities to impaired development of the brain area in question. The third, a 'neuroconstructivist' model, suggests that structural abnormalities can arise, through the course of development, from an interaction between genetic expression, environmental factors and behaviour (Mareschal et al., 2007; Thomas & Karmiloff-Smith, 2002). Lesion-deficit models draw a parallel between the outcomes of acquired brain damage and similar functional impairments during development, and assume that specific functional impairments arise from specific lesions. Neuroconstructivist models acknowledge the possibility of predisposition, but recognise the connectionist nature of the brain and the iterative nature of the interaction between the brain and the child's experience (Mareschal et al., 2007).

Structural and functional abnormalities found in the brains of many autistic individuals include pervasive abnormalities and those in specific locations. Pervasive abnormalities have included: smaller pre-natal head circumference with

rapid post-natal increase (Courchesne et al., 2003); frontal lobe hyperplasia with no corresponding overgrowth in dorsal areas (Carper et al., 2002); abnormal cortical organization (Bailey et al., 1998; Belmonte et al., 2004); abnormal minicolumn structure in frontal and temporal areas (Casanova et al., 2002); and variations in white and grey matter (Courchesne et al., 2003). Specific locations showing abnormalities include: orbitofrontal cortex, (e.g. Sabbagh, 2004) anterior cingulate (Frith and Frith, 2000); amygdala (e.g. Baron-Cohen et al., 2000); superior temporal sulcus (e.g. Castelli et al., 2002); dorsal vermis of the cerebellum (e.g. Courchesne et al., 1994); and corpus callosum (Saitoh et al., 1995).

Processing secondary information, such as retrieval of perceptual knowledge relies on brain regions used to mediate sensory experiences with the referenced objects (Goldberg et al., 2006). The predominance of abnormalities in regions processing secondary information has led to inferences that autism affects higher-level cortical function leaving primary sensory processing relatively intact (e.g. Brownell et al. 2000), supported by the finding that hyperplasia shows a decreasing gradation from frontal to dorsal areas (Carper et al., 2002). For example, Brownell et al. (2000) state that the prefrontal regions of the brain ‘‘support a person’s ability to select from among representations that are divorced from sensory input’’ (p. 325). The prefrontal areas do process abstracted representations, but the initial formation of those representations is entirely dependent on sensory input from the internal and external environment.

Neuroimaging research has identified structural brain abnormalities in ASD, which coincide with brain regions involved in executive functions. Therefore, Sanders et al. (2008) reviewed the literature on four specific executive functions in ASD: sustained attention, orienting attention, response inhibition and set shifting. They found that deficits in orienting attention, response inhibition and set shifting exist in ASD, but sustained attention ability appears to be normal.

1.7 ASD and Comorbidity with Psychological Disorders

Individuals with developmental disabilities are at increased risk for developing a variety of co-occurring mental health conditions compared to children with a history of typical development (White et al., 2009). The majority of the empirical research on co-morbidity of ASD points towards mood problems with anxiety disorders among the most common psychiatric conditions that present during childhood and often co-occur with other diagnoses, such as disorders of attention, mood, conduct, and development (Compton et al., 2004; Dadds & Barrett, 2001; Kendall, Brady, & Verduin, 2003).

1.7.1 Anxiety in ASD

Tantam (2000) stated that anxiety is almost universally comorbid with Asperger syndrome and that high trait anxiety is a common feature of individuals across the spectrum of autism. Anxiety is likely to occur at twice the rate of TD children (Costello et al. 2005).

De Bruin et al. (2006) found more than 55% of their sample of children with ASD met criteria for at least one anxiety disorder. In a more recent meta-analysis study by Van Steensel et al. (2011), the most common co-occurring anxiety disorders in children with ASD were specific phobia (29.8%), OCD (17.4%), and social anxiety disorder (16.6%).

Individuals with ASD represent a diverse clinical group, which often makes diagnosis and intervention for anxiety quite difficult. Individuals with ASD and an anxiety disorder present with particularly complex behaviours that require a unique approach to treatment (ibid). One factor that leads to confusion for clinicians making diagnosis and intervention is the wide variability of characteristics within the autism spectrum. In order to explore whether there may be an influence of core characteristics of ASD with anxiety, it is necessary to firstly examine the relationship between ASD and anxiety by looking at the nature of ASD as a complex disorder with multiple core deficits.

a. Prevalence

There are a growing number of studies of anxiety in children and adolescent with ASD which focus on prevalence. Van Steensel et al. (2011) conducted a systematic review involving 31 studies, 2,121 young people, aged <18 years with ASD. Across studies, 39.6% of young people with ASD had at least one comorbid DSM-IV anxiety disorder, the most frequent being specific phobia (29.8%) followed by OCD (17.4%) and social anxiety disorder (16.6%). Associations were also found between specific anxiety disorders and ASD subtype, age, IQ, and assessment method (questionnaire versus interview). Previously, Bellini (2004) found that levels of anxiety in ASD is significantly higher than controls by 49%. In another study, Bradley et al. (2004) showed that 42% of an ASD sample reached clinical significance for anxiety and de Bruin et al. (2006) found that anxiety disorders were the second most prevalent comorbid condition with 55.3% of their sample having at least one anxiety disorder. Simonoff et al. (2008) further reported that, 41.9% of the participants met criteria for at least one anxiety disorder. Social anxiety disorder was the most common disorder (29.2%). A further study by Sukhodolsky et al. (2008) has showed that 43% met screening cut off criteria for at least one anxiety disorder. They also found that higher levels of anxiety are associated with higher IQ, functional language use and stereotyped behaviour.

b. Impact of anxiety in ASD

Diagnostic Overlap

The diagnostic characteristics of ASD include impaired social skills, delayed development of language, and repetitive or restrictive interests or body movements. Individuals with co-occurring ASD and an anxiety disorder present with particularly complex behaviours that require a unique approach to treatment. Researchers and clinicians have subsequently considered anxiety as both a possible consequence of, and possible cause of, aspects of the behaviour of children with autism (Gillot et al., 2001).

Gadow et al. (2008) examined mental health risk/protective factors for DSM-IV psychiatric symptoms in children with an autism spectrum disorder (ASD) and their contribution to functioning separate from ASD symptom severity.

Findings indicate that co-occurring psychiatric symptoms and their associated mental health risk/protective factors may have important clinical implications and generally support a bio psychosocial model of psychopathology in children with an ASD.

Relative severity of psychiatric symptoms likely impacts on clinical decision making and in many situations actually defines the targets for intervention. Owing to the truly modest attention this topic has received over the course of several decades, we are now only beginning to translate research findings into recommendations for clinical practice. One recent effort was to incorporate psychiatric symptom ratings into screening instruments for ASD (e.g. De Vincent et al., 2008)

There is emerging evidence also for relationships between anxiety, sensory hypersensitivity (Pfeiffer et al., 2005) and degree of social impairment (Bellini, 2004). Frequently ASD features such as sensory over responsivity (SOR) and anxiety tend to be correlated and due to diagnostic overlap may be difficult to distinguish. Scales of SOR and anxiety disorders both include behavioural items that may indicate either SOR or anxiety, such as avoidance of mess and startle response to sound (Green & Ben-Sasson, 2010).

Ben-Sasson et al. (2007a) investigated this problem by studying how occupational therapists differed from psychologists in their judgment of symptoms as representative of SOR versus anxiety in toddlers. The authors found that occupational therapists tended to rate items as representing SOR while psychologists tended to rate the same items as representing anxiety disorders. There were six items from anxiety or SOR scales that at least 80% of psychologists and occupational therapists rated as indicators of both conditions. In addition, in response to a vignette case study representing SOR, all occupational therapists diagnosed SOR while 26% of psychologists diagnosed an anxiety disorder, whereas in response to a vignette case study representing general anxiety 50% of occupational therapists diagnosed SOR and 92% of psychologists diagnosed an anxiety disorder. Thus, both professional background and item overlap may contribute to diagnostic overlap.

Chapter 2.

Overview of Executive and Sensory Processing Dysfunctions in Relations to Anxiety in ASD

2.1 Introduction

ASD is a chronic, life-long condition that is among the most debilitating of the developmental disabilities. Matson and Cervantes (2014) found that the most common comorbid psychopathology among persons with ASD are ADHD, anxiety and depression. Central to the entire study of comorbid psychopathology of ASD is the understanding of possible factors affecting clinical presentations these psychopathology in young people with ASD. It is estimated about 40% of children with ASD fulfilled diagnostic criteria for an anxiety disorder (van Steensel et al. 2011) and as many as 84% have impairing, subclinical anxiety symptoms (White et al. 2009).

Recent developments in the field of ASD have led to a renewed interest in behavioural and neuropsychological markers underlying the spectrum of autism as part of 'gold standard' approach to ASD diagnosis. One of the attempt is through exploring executive functions, and sensory processing, associated with anxiety. In this chapter, an overview of executive function, sensory processing and anxiety symptoms in children with ASD will be discussed.

2.1.1 Executive Function Deficits in ASD

Kanner (1943) emphasized the social deficits in ASD when the syndrome was first described. Difficulties with social interaction and social relationships (e.g. Lord, 1993) and investigations in adaptive skills in ASD have been consistently reported particularly in the area of socialization (e.g. (Rodrigue, Morgan, & Geffken, 1991; Volkmar et al., 1987).

Gillotty et al. (2002), examined the relationship between executive abilities and adaptive behaviour in 35 children with ASD. They found that initiation and working

memory domains were negatively correlated with most domains of adaptive behaviour. The communication and socialization domains of the Vineland Adaptive Behaviour Scales (VABS; Sparrow et al., 1989) were negatively correlated with several areas of executive functioning, suggesting that impairments in executive abilities are strongly associated with the deficits in communication, play and social relationships found in children with autism. Thus, deficits in executive processes may contribute to the problems with reciprocity in social interactions that characterize children with autism.

A small number of studies have compared executive functioning profiles between children with ASD and those with an anxiety disorder. For example, Zandt et al. (2009) studied neurocognitive patterns of functioning, with executive functioning (EF) impairments being hypothesized in both ASD and Obsessive Compulsive Disorders. Performance on neuropsychological tests assessing executive functioning showed a trend for children with ASD to perform poorly on tasks requiring generation of multiple responses, while children with OCD tended to demonstrate impairments on a task requiring inhibition. Parental ratings on a questionnaire measure of EF indicated impairments in both groups relative to typically developing controls.

Research focusing on neuropsychological features of anxiety disorders points towards possible deficits in organizational strategies in general, suggesting problems in executive functioning. Results of investigations into neuropsychological functioning have been inconsistent so far. Several studies with participants with OCD suggest impairments on tests of set shifting, fluency, planning and problem solving and visuospatial memory. The majority of studies suggest that OCD is commonly associated with mild cognitive dysfunction on tasks involving executive functioning and nonverbal memory (e.g, Greisberg & McKay, 2003; Kuelz, Hohagen & Voderholzer, 2004a).

Given that ASD is associated with the presence of both EF deficits and anxiety, a next logical step is to explore whether there are important relationships between these two features of the disorder and whether EF deficits are associated with a specific anxiety profile in ASD.

2.1.2 Sensory Processing Dysfunctions

Little attention has been given to examining the relationship between SP and either the core symptoms or secondary manifestations of autism (Baker et al., 2008). Affective disorders such as depression and anxiety have been theorized to have a relationship with hyposensitivity and hypersensitivity to environmental sensory stimuli (Neal, Edelmann, & Glachan, 2002). Individuals with Pervasive Developmental Disorders may have sensory modulation disorders that lead them to under or over respond to sensory stimuli in their environment (Hanft, Miller, & Lane, 2000).

In one of the few studies that integrated paradigms from occupational therapy and clinical psychology, there is emerging evidence for relationships among anxiety and sensory hypersensitivity in ASD (Pfeiffer et al., 2005). Other research suggests that sensory over-responsivity (SOR) predicts anxiety and significant correlations have been found between the degree of sensory abnormality and level of restricted and repetitive behaviour reported (e. g. Green et al., 2011 & 2010; Baker et al., 2008).

Dunn (1997) identifies that individuals who under respond to sensory stimuli, demonstrating hyposensitivity, have a high neurological threshold requiring more intense amounts of input in order to register and elicit a response. In some of the literature, this is called sensory dormancy (Lai, Parham, & Johnson-Ecker, 1999). In contrast, children who over-respond have a low neurological threshold, resulting in strong reactions to sensory stimuli with very minimal input. This phenomenon is termed sensory defensiveness due to the behavioural responses associated with hypersensitivity or over responsiveness. For example, individuals with sensory defensiveness often avoid or demonstrate distressed responses to sensory stimuli in the environment. Specifically, sensory defensiveness is a fight or flight reaction to the same sensory stimuli considered by others to be non-noxious (Bundy, Lane, & Murray, 2002).

The sensory perceptual abnormalities associated with ASD include tactile defensiveness, auditory hypersensitivity, olfactory hypersensitivity and sensory overload, hypo reactivity and hyper reactivity to sensory stimuli and faulty modulation of sensory input. In particular, a number of studies have found that

impairment in auditory processing is one of the most commonly reported sensory processing impairments in children with ASD (Tomcheck & Dunn, 2007).

Children with ASD often exhibit related symptoms or symptom clusters, which can significantly increase their functional impairment. One such symptom cluster is sensory over-responsivity (SOR), an often clinically impairing condition characterized by heightened and unusual reactivity to sensations (Ben-Sasson et al., 2010), which occurs more frequently among children with ASD (e.g., Baranek et al., 2006) than among typically developing children (e.g., Ben-Sasson et al., 2008). Critical to the current PhD research, SOR has been reported to predict the development of anxiety in children with ASD (e.g. Ben-Sasson et al., 2009).

Few studies have sought to investigate the relationship between SP difficulties and the clinical manifestations of ASD. Miller et al. (2005) found that children with high functioning autism or Asperger syndrome with lower arousal and who habituate to repeated sensory stimuli, tend to have greater communication and social impairment as well as increased repetitive behaviours. Kern et al. (2007b) concluded that multi-sensory disturbance was positively associated with autism severity in children but weakened in adolescents and adults.

Similarly, Hilton et al. (2007a) reported that social impairment in school-aged children with high functioning autism was positively associated with SP disturbances. Baker et al. (2008) found consistent moderate to strong correlations between SP difficulties across domains and the presence of maladaptive behaviours. In particular, significant associations were found between SP dysfunction and parent-reported child anxiety, social relating, communication disturbances, self-absorption and antisocial behaviours. Liss et al. (2006), reported a relationship between sensory over-responsivity in ASD and perseveration and over focusing attention. Further, sensory under-responsivity was associated with lower adaptive functioning and poorer communication and social performance.

As noted, research suggests that SOR is a predictor of anxiety in children with ASD (Ben-Sasson et al., 2009; Liss et al., 2006; Pfeiffer et al., 2005). However, the reason for the co-occurrence of SOR and anxiety is unknown, and there is little research on the development of SOR and anxiety symptoms in children with ASD. Green and Sasson (2010) reported that causal mechanisms may exist between

SOR and anxiety. In another study, Green et al. (2011) focused on the emergence of and bidirectional effects between anxiety and sensory over responsivity (SOR) in toddlers with autism spectrum disorders (ASD). SOR positively predicted changes in anxiety over and above child age, autism symptom severity, non-verbal developmental functioning, and maternal anxiety, but anxiety did not predict changes in SOR. Results suggest that SOR emerges earlier than anxiety, and predicts later development of anxiety.

Pfeiffer et al. (2005) attempted to determine whether there were any significant relationships between dysfunction in sensory modulation, symptoms of affective disorders, and adaptive behaviours in children and adolescents with Asperger's disorder between 6 and 17 years of age. The results indicated that there were significant strong positive correlations between sensory defensiveness and anxiety. Thus, heightened sensitivity to environmental stimuli and sensory modulation dysfunction appear to be related to anxiety in people with AS, although the precise association and direction of causality requires further investigation (White, 2009).

The research evidence is however not without its limitations. Apart from the failure to use appropriate control groups, many studies used limited behavioural indicators of sensory abnormality, often centred on sound and touch. In addition, lack of agreed convention among clinical researchers as to how common autistic behaviours should be categorized makes it difficult to evaluate and compare research findings. A frequent limitation in the experimental studies is a failure to consider developmental and maturational effects in samples and control group selection. Ecological validity may also indeed be a critical issue in advancing understanding and presents major challenges to investigators in this field.

It is important to try to understand sensory problems in autism because it can enable us to better understand the needs of people with autism and in turn, influence treatment protocols (Kern et al., 2006). Specifically, studying the emergence of both anxiety and sensory processing in young children as well as simultaneously examining whether each one predicts change in the other can help us understand the direction of effect, given that it is as yet unclear what reciprocal patterns (if any) exist between anxiety and SOR (Green & Ben-Sasson, 2010).

2.1.3 Aims of the current study

The main aims of this study are:

a. To identify subgroups of children with ASD and anxiety according to their performance on executive tasks and the presence of sensory processing abnormalities.

b. To describe any associations between anxiety subtypes and ASD specific phenotypic behaviours (executive function profile and abnormalities in sensory processing) in children with ASD.

Therefore, specific aims are as follows:

a. To summarize the current research on anxiety in relation to EF and SP dysfunctions in ASD

b. To identify recurring patterns of themes in the literature, in relation to the review aims using a narrative approach.

c. To systematically review the quality of the literature to ascertain confidence in any conclusions drawn.

d. To consolidate the findings of the review in order to propose a preliminary model of anxiety in ASD and potential areas for further research.

e. To determine the relationships between executive functions and sensory processing in relation to anxiety in children with ASD.

f. To identify subgroups of children with ASD on anxiety, according to their performance on executive functioning task and their SP atypicalities.

g. To explore any possible associations between specific anxiety subtypes and ASD specific phenotypic behaviours.

h. To explore the associations between specific EF subtypes and anxiety

i. To examine the relationship between particular EF tasks and OCD characteristics in children with ASD.

j. To examine the relationships between parental reports of executive functioning, anxiety and restricted and repetitive behaviours in young people with ASD with particular focus will be given to OCD.

k. To explore changes in parent reports of anxiety over time (anxiety profiles at study 1 and study 2).

Chapter 3. Literature Review of the Influence of Executive and Sensory Processing Dysfunctions on Anxiety in Children with ASD

3.1 Introduction

3.1.1 Overview of anxiety in ASD

Anxiety related concerns are among the most common presenting problems for school-aged children and adolescents with ASD (Ghaziuddin, 2002). Co-occurring anxiety problems may compound the overall social impairment in children with ASD (White et al., 2010). Anxiety seems to have a bidirectional effect and interact with the core disabilities of ASD. White et al. (2009) conducted a systematic review of anxiety in children and adolescents with autism. The results of the review suggest that anxiety is indeed common in children and adolescents with ASD and may be source of additional morbidity.

It is evident that anxiety is a problem for individuals with ASD, however the relationship between ASD and anxiety is not fully understood. Research to date also has not yet explained the connection between the core characteristics of ASD and anxiety.

3.1.2 Rationale of choosing EF and SP as review construct

Executive function is the cognitive construct used to describe goal-directed behaviour which is mediated by the frontal lobes (Duncan, 1986). Deficits in EF result in disorganization of behaviour (*ibid*). One of the first studies to document a relationship between social and executive processes in ASD was conducted by McEvoy et al. (1993), who reported that performance on executive tasks was significantly correlated with measures of social interaction, including joint attention in preschool-aged children with autism.

Research in autism and Obsessive Compulsive Disorders (OCD) in ASD indicates several shared similarities in terms of symptom profiles and etiologic overlap, especially in terms of cognitive, neurobiological and genetic aspects (Fischer-

Terworth & Probst, 2009). Children with ASD have been reported to perform poorly on tasks requiring generation of multiple responses, while children with OCD tended to demonstrate impairments on tasks requiring inhibition (Zandt et al., 2009). More recently, Hollock et al. (2013) found a significant association between poorer executive functioning and higher levels of anxiety among adolescents with ASD.

There is emerging evidence also for relationships between anxiety, sensory hypersensitivity (Pfeiffer et al., 2005) and degree of social impairment (Bellini, 2004). Frequently ASD features such as sensory over responsivity (SOR) and anxiety are reported to be correlated, however this may be due to diagnostic overlap as the symptoms of the two can be difficult to distinguish (Green et al., 2012). Ben-Sasson et al. (2007a) examined how occupational therapists differed from psychologists in their judgment of symptoms as representative of SOR versus anxiety in toddlers with autism. Findings indicate that both professional background and item overlap may contribute to diagnostic overlap.

Behavioural overlap is also evident in parent-report measures of SOR and anxiety. Scales of SOR and anxiety disorders include behavioural items that may indicate either SOR or anxiety, such as avoidance of mess and startle response to sound (Green & Ben-Sasson, 2010). Further a study on the causal relationships between SOR and anxiety suggests that SOR emerges earlier than anxiety, and predicts later development of anxiety (Green et al, 2012).

3.1.3 Rationale for the Review

To date, no reviews have been conducted looking at the relationships between anxiety and EF difficulties or SP atypicalities in children with ASD. The current review will explore these potential relationships in detail, looking at studies which have explored the relationship between anxiety and EF and anxiety and SP in ASD. The aim of these reviews is to synthesize and critically review the empirical evidence pertaining to these relationships. Therefore, the objectives are as follows:

a. To summarize the current research on anxiety in relation to EF and SP dysfunctions in ASD

b. To identify recurring patterns of themes in the literature, in relation to the review aims using a narrative approach.

c. To systematically review the quality of the literature to ascertain confidence in any conclusions drawn.

d. To consolidate the findings of the review in order to propose a preliminary model of anxiety in ASD and potential areas for further research.

3.1.4 Review Questions

This review chapter discusses the evidence for the relationship between executive and sensory processing dysfunctions and anxiety in ASD. In particular, the review will endeavour to answer the following questions:

a. Is executive dysfunction a neuropsychological deficit which relates to anxiety in children with ASD?

b. Are sensory atypicalities related to anxiety in children with ASD?

3.2 Method

Two reviews were conducted in order to investigate the above questions. This is because of the different constructs being studied. The first review will look for evidence of relationship between executive dysfunctions and anxiety (question one). The second review will investigate the studies focusing on relationship between sensory atypicalities and anxiety (question two).

3.2.1 Method of Review: Question One

A mixed method has been adopted in this review to obtain a fuller picture of anxiety phenomena in ASD. A systematic approach was undertaken to identify papers for

inclusion and to address the quality of the papers. A narrative approach was then used to interpret the findings and to look for the recurring themes in the literature.

3.2.2 Criteria for selecting Studies

a. Inclusion and Exclusion Criteria

Date range

All dates included. The range of the date was determined by the databases. The automatic default published 'All Years' to 'Present' was chosen.

Populations studied

Studies were included when participants were aged 8 to 16 years old, or the mean age of the ASD sample was within this range. This age range was chosen because this is the most common time for anxiety difficulties to emerge in childhood. Where child participants had a range of differing diagnoses, the study was included if ASD outcome data were presented separately, and if half or more of participants had ASD. In this search, both males and females, children with autism, Asperger syndrome, Pervasive Developmental Disorder Not Otherwise Specified (PDD-NOS) diagnoses were included. All cultural groups were also included.

Language

Written in English.

Source of paper

In the database searches, only the peer reviewed journal articles were included. Searches in grey literature were also conducted in order to minimise potential

publication bias and the risk of relevant literature being omitted. To further address publication bias, key authors in the area were contacted to request any available unpublished or soon to be published literature.

3.2.3 Exclusion Criteria

a. Review studies (e.g. systematic review).

b. Papers that do not have clear measures, analyses and result about EF or anxiety.

c. Studies about interventions (e.g. pharmachotherapy or psychotherapy), where investigation of the association between the two core constructs was not examined.

3.2.4 Search strategy

a. Definition of concepts

The main terms were ASD and anxiety and executive function. ASD was described in the literature as Pervasive Developmental Disorder with a range of conditions that includes autism, Asperger syndrome, pervasive developmental disorder not otherwise specified (PDD-NOS), childhood disintegrative disorder, and Rett syndrome. Usually only the first three conditions are considered part of the autism spectrum. In this study only the terms autism and Asperger syndrome were used in the search.

b. Definition of keywords

Key concepts were transformed into key words for use in the database searches. Truncations (*) were employed to make sure that terms with multiple suffixes were captured in the search process. This was an iterative process whereby initial, preliminary database searches were used to develop the keywords used. Table 3.1 below shows search terms utilised during database searches.

Table 3.1

Search terms utilised during database searches.

Concept	Search term
1. Anxiety	anxi* (anxiety/anxious)
2. executive function	Executive function* (functions/functioning)
3. Autism Spectrum Disorder	Autis* (autistic/autism/autism spectrum disorder) Asperg*(Asperger Syndrome)

c. Searching EF in relations to anxiety subtypes

Due to reported relationship between EF and Obsessive-compulsive Disorder (OCD; eg South et al., 2007 and Zandt et al., 2009), an attempt was made to perform databases scoping using the following keywords:

Table 3.2

Search terms utilised during searching for relationship between EF and OCD

Concept	Search term
1. Anxiety	Obsessive-compulsive* (disorder/disorders)
2. Executive function	Executive function* (functions/functioning)
3. Autism Spectrum Disorder	Autis* (autistic/autism/autism spectrum disorder) Asperg*(Asperger Syndrome)

d. Application of Boolean Operators

During database searches, firstly all terms for anxiety were combined into one set using the Boolean operator “OR”. This was repeated for all search terms related to the concept of executive functions and ASD. The anxiety concept was then combined with each of the 3 remaining concepts using the Boolean operators “AND”. In the OVID Medline, Embase and PsycINFO databases, the “Explode”

function searches was used for an index term of “anxi*”, “executive function*”, “autis*” and “asperg*”. It was then automatically ORs with all of its narrower terms.

f. Limits of Search

The search was also limited to human studies, English language and peer reviewed journals. The default (‘child (6 to 12 year) “or” adolescent (13 to 18 years) was chosen in order to fulfil our age inclusion criteria wherever available on the databases.

g. Summary of Search terms in stage 1

The summary of search terms used in stage 1 after application of truncation, Boolean Operators and limits are as per following table:

Table 3.3

Summary of search terms in stage 1

Order	Terms
1.	Exp anxiety/
2.	Exp executive function/
3.	Exp autistic disorder/
4.	1OR2OR3
5.	*Asperger Syndrome/
6.	4AND5
7.	Limit 6 to (English language and humans an (‘child (6 to 12 year) “ or ” adolescent (13 to 18 years)”) and journal article)’

3.2.5 Retrieval Sources

The following resources were searched utilising the search strategy outlined.

a. Electronic databases.

The search strategy involved systematic searching of several electronic databases such as Medline, Embase, PsycINFO, Web of Knowledge (WoK), Scopus and Ovid. In Embase, Medline and PsychINFO, database searches were carried using keywords. Topic search was used in Web of Knowledge (WOK), and using article title, abstract and keyword search in Scopus. This resulted a total of 1774 hits which were exported to Endnote. Kindly refer to **Appendix A** (Electronic databases searched and number of hits acquired at stage 1)

b. Author search.

The author search was done based on author names that are prominent in the area of executive function and anxiety in ASD. Therefore, the following author names were searched using the online databases:

Hollock, M.
Hill, E.
Zandt, F.
Pellicano, E.

This search has resulted in no additional papers.

c. Hand journal search.

Hand journal search was done on the following journals:

a. Journal of Autism and Developmental Disorders (Springer)
b. Autism Research (WILEY)
c. Autism (SAGE)

This has resulted with no additional papers.

d. Grey literature search.

Searches were also carried out in Google and Google Scholar. This has resulted in an addition of one paper (Lawson et al., 2014).

3.2.6 Additional search strategies.

a. Author contact.

A number of authors were identified as key authors and contacted to ask for any unpublished papers. This has resulted in no additional number of papers.

a. Hollock, M.
b. Hill, E.
c. Zandt, F.
d. Pellicano, E.

Three authors (Hollock, M., Zandt, F and Pellicano, E.) had replied that they had are no unpublished papers or soon to be published papers in the area of executive functioning and anxiety in children with ASD. This has resulted in no additional papers.

b. Cited references.

The references of relevant papers were examined to check for cited papers. This resulted in 1 additional paper.

3.2.7 Screening and Selecting

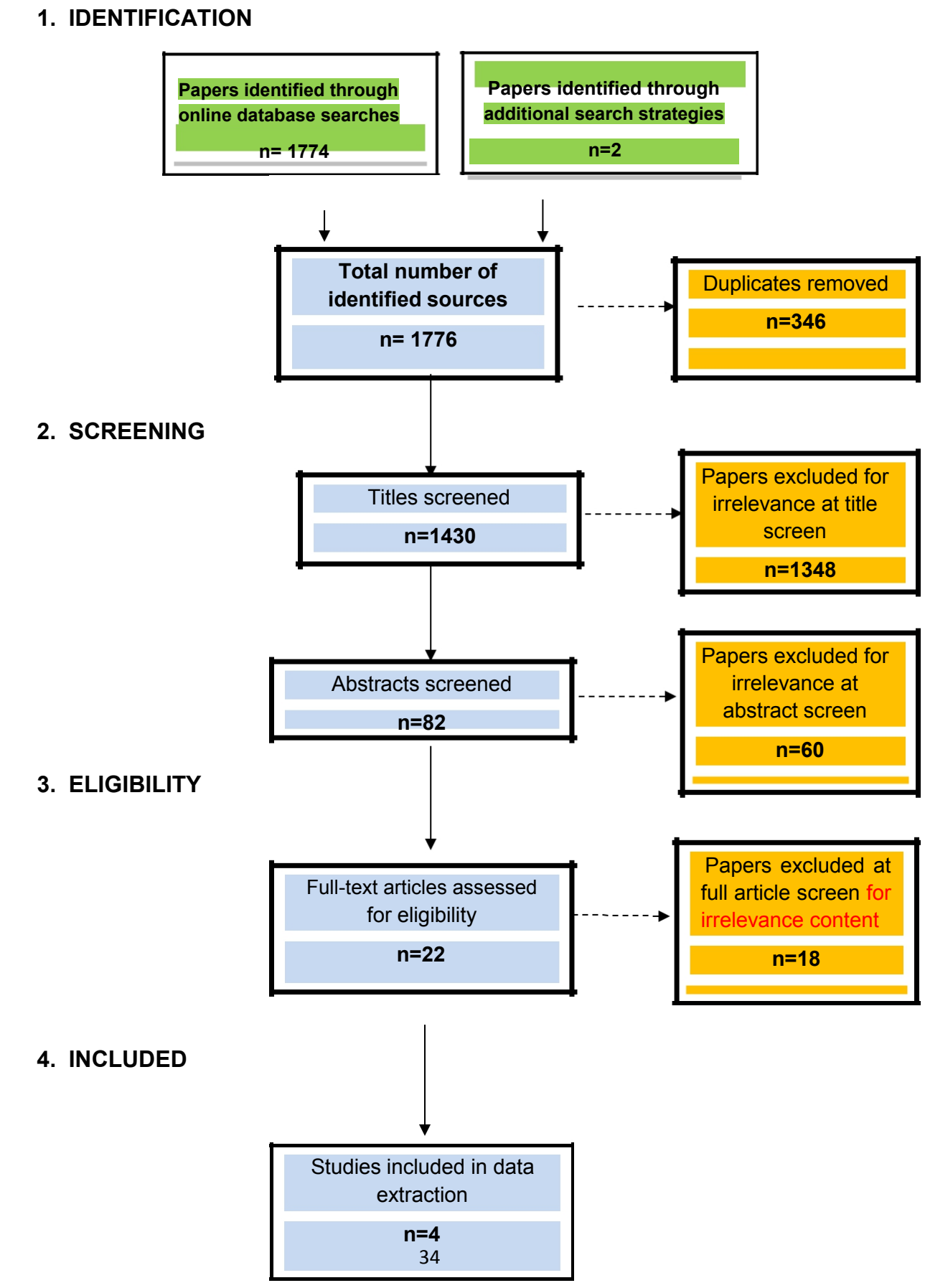
The papers that were identified through the search process (after removing duplicates) were exported to endnote where they were then filtered by:

a) Title Relevance.
b) Abstract Relevance.
c) Full Paper Relevance.

At the stage of full paper screening, the participants were also carefully screened to ensure that the study representing children with ASD aged between 8 to 16 years old. Four papers meet the full inclusion and exclusion criteria. Figure 3.1 shows the process of screening and filtering of papers.

Figure 3.1

Screening and filtering of papers



3.2.8 Journals

Selected studies came from the following journals:

1. Journal of Autism and Developmental Disorders - (1 article)
2. Autism Research - (1 article)
3. Autism - (1 article)
4. Neuropsychology - (1 article)

3.3 Results

3.3.1 Summary of Identified Papers

Four papers met the full inclusion criteria and the key information was extracted and is summarized in table 3.4.

3.3.2 Populations studied.

Only one of the studies included only ASD samples, 1 study included an ASD and an Attention Deficit Hyperactive Disorder (ADHD) sample, 1 study included an ASD and an OCD sample and another one study included an ASD and a Bipolar Disorder (BD) sample. Two studies included typically developing (TD) samples as controls.

3.3.3 Measures used

a. Measures of Executive Functions.

A number of measures of Executive functions were utilised. These included measures which specifically purport to measure specific EF functions such as Fluency, Generativity, flexibility and inhibition. Kindly refer to table 3.4, Summary of papers under review.

b. Measures of anxiety.

Measures of anxiety are also varied. Most of the measures used are part of the overall emotional or behavioural assessments, except two studies that utilized direct anxiety measures (CY-BOCS and SCAS-C; Zandt et al., 2009 and Greenaway and Howlin, 2010). Kindly refer to table 3.4, Summary of papers under review.

Table 3.4

Summary of papers under review

Paper	Aims/ Hypothesis	Participants	Measure of anxiety	Measure of EF	Statistical Analyses	Result/ Conclusion
1. Greenaway and Howlin (2010)	- To explore whether dysfunctional and/or perfectionistic attitudes are elevated in children with ASD compared to typically developing children. - To explore whether these are also related to anxious and depressive symptoms - To explore whether dysfunctional and/or perfectionistic attitudes are related to cognitive inflexibility.	-41 ASD children aged 11-14 years (mean, 13.2 years) -42 typically developing control (mean, 13.2 years)	-SCAS	-WCST	-Correlation Analysis	- ASD group has more dysfunctional attitudes and reported higher emotional symptoms - The elevated dysfunctional attitudes are related to cognitive inflexibility and social impairments. - The relationship between emotional and cognitive variables was weak in both ASD and control.

2. Hollocks et al. (2013)	- To examine independent relationships between multiple measures of EF and social cognition on severity of anxiety or depression	-90 adolescents with ASD -no controls	-SDQ -PONS	- The opposite world task - Trail making - The Digit Span task from CMS. - Card Sorting task (WSCT)	-Correlation Analysis - Regression analysis	- Significant association between EF and anxiety
3. Lawson et al. (2014)	To test two mediation hypotheses: - Parent reported flexibility problems mediate the association between ASD/ADHD diagnostic status and anxiety/depression - Parent reported inhibition problems mediate the association between - ASD/ADHD and ODD/CD.	-125 children between the ages of 6 and 16. -70 ASD and 55 ADHD	- CBC	- BRIEF.	- ANOVA - Correlation Analysis	- ASD predicted greater inflexibility which predicted greater anxiety/depression, while ADHD predicted - Greater disinhibition predicted greater aggression.

4. Zandt et al. (2009)	- To compare EF in ASD and OCD - To explore relationship between RRBs and EF.	- 54 children and adolescent (aged 7 to 16 years) -19 ASD, Mean age of 11 years (SD=2.42) -17 OCD, mean age of 12 years (SD=2.17). -18 controls, mean age 12 years (SD=2.94).	- CY-BOCS.	- The Verbal Fluency Task. - The Concept Generation Task-Child version. - The Rey Osterrith Complex Figure Test. - The Don't walk task. -BRIEF	- ANOVA - Correlation Analysis.	- Children with ASD perform poorly on task requiring multiple responses. - EF impaired in both ASD and OCD groups

Key: **SDQ** – Strength and difficulties Questionnaires; **PONS** – Profile of Neuropsychiatric Symptoms; **CMS** - Children's memory Scale; **WSCT** - Wisconsin Cart Sorting; **HFA** – High Functioning Autism; **ADHD** – Attention Deficit Hyperactive Disorder; **ODD/CD** – Oppositional Defiant Disorder/Conduct Disorder; **BRIEF** – Behaviour Rating Inventory of Executive Function; **ANOVA** – Analysis of Variance; **BD** – Bipolar Disorder; **SCWT** - The Stroop Color-Word Test; **K-SADS-IV-R** - The Schedule for Affective Disorders and Schizophrenia for School Age Children; CBCL – The Child Behaviour Checklist; **CPT** - The Conner's Continous Performance Test; **SCAS** – Spence children's Anxiety Scale; **CY-BOCS** – The Children's Yale-Brown Obsessive Compulsive Scale; **OCD** – Obsessive - Compulsive Disorder; **BRIEF** – Behaviour Rating Inventory of Executive Functions.

3.4 Methodological Quality of Studies

Thorough reading of the final papers under review identified their differences and similarities with regard to design, samples, measures and results. Therefore, the next important step is to highlight the strengths and weaknesses of the papers in order to be able to deduct which papers are the most usefully interpreted with regard to the review questions outlined in stage one. The CRD (2008), recommends that any pre-existing checklists or scales be modified to suit the needs of the specific review. Consequently a grid was specifically developed for the present review, guided by a number of existing grids, as well as previous reviews and relevant literature in the area of ASD.

Therefore, the quality checklist for studies under review was developed by consulting guidelines in the literature (Ramos-Alvarez et al., 2008 and SIGN, 2008), existing quality checklists (Law et al. 1998; SIGN, 2008) and a review study in anxiety (White et al, 2009). In terms of measures for EF and anxiety, the review study on EF by Hill (2004) and a systematic review on anxiety measures in children (Wigham and McConachie, 2014) was heavily consulted. Since this grid will be used in review stage two also, the recent review on sensory abnormalities in ASD by Hazen et al. (2014) was also consulted.

The introduction, methods, results, and discussion (IMRAD; Huth, 1987) structure was chosen due to its utility in facilitating modular reading (Sollaci & Pereira, 2004). Kindly refer to **Appendix D** for Potential Threat Scoring Criteria in this review and the Methodological qualities evaluation for review stage one is as per table 3.5.

Table 3.5

Methodological Qualities of Studies

Domain	Criterion	Greenaway & Howlin, 2010	Hollocks et al., 2013	Lawson et al., 2014	Zandt et al., 2009
A. INTRODUCTION	Are the aims, hypotheses and objectives clearly described for the constructs being studied (EF and anxiety)?	3	2	2	2
Domain A Total Score/3		3	2	2	2
B. METHODOLOGY	Does the recruitment methodology evidence an attempt to gain a sample that is representative of the study population?	3	1	1	3
1. **PARTICIPANTS**	Are the inclusion and exclusion criteria justified?	**1**	**2**	**3**	**2**
	Are sample characteristics described (age, gender, ASD subtypes, Comorbidities, medication use and demographic variables)?	**2**	**3**	**3**	**2**
	Was ASD diagnosis confirmed for the study?	**4*(2)**	**6*(3)**	**6*(3)**	**4*(2)**
	Was level of cognitive functioning of participants assessed?	**3**	**1**	**3**	**3**

	Are the participants appropriate to answer the research question?	**3**	**3**	**2**	**3**
1.DESIGN	Was the design appropriate for the study question? (e.g., for knowledge level about this issue, outcomes, ethical issues, etc.)	3	2	1	2
	Any biases that may have been operating have been specified and the direction of their influence on the results were mentioned?	3	0	3	3
2.MEASURES	Was an anxiety measured using standardized, valid and reliable measures?	3	1	1	1
	Were the measures of anxiety used – appropriate for ASD population?	1	1	1	1
	Was EF measured using standardized, valid and reliable measures?	**2*(1)**	**2*(1)**	**2*(1)**	**2*(1)**
	Were the measures of EF used appropriate for ASD population?	1	1	1	1
	Based on the above, how well was assessment done to reduce bias and to gain accurate outcome measures?	1	2	1	1
Domain B total score		**30** (27)**	**25** (21)**	**28** (24)**	**28** (25)**

C. RESULTS/ ANALYSIS	Is the statistical analysis appropriate to the design?	2	3	2	3
	Are descriptive statistics provided?	0	3	2	3
	Is appropriate supplementary information provided (i.e. effect sizes, power)	0	2	2	3
	Do the results allow inferences to be made about the relationship between EF and anxiety in ASD specifically?	**2*(1)**	**4*(2)**	**4*(2)**	**6*(3)**
Domain C total score		**4**(3)**	**12**(10)**	**10**(8)**	**15**(12)**
D. DISCUSSION	Do the conclusions follow adequately from results?	2	2	2	3
	Are limitations acknowledged?	3	2	3	3
Domain D total score/6		5	4	5	6

*Key Criteria double rated. The original score is indicated in parentheses ( ).

**Domain total score after double rated score was added. The original domain total score is indicated in parentheses ( ).

3.5 Key criteria of sensitivity for review studies

The following section should be read in conjunction with table 3.5 above (Methodological Qualities of studies). From the above table, there are three key criteria of sensitivity that has been chosen for this study:

a. Was ASD diagnosis confirmed for the study?
b. Was EF measured using standardised, valid and reliable measures?
c. Do the results allow inferences to be made about the relationship between EF and anxiety in ASD specifically?

The key criteria “Was anxiety measured using standardised, valid and reliable measures?” was not included as a key consideration as for review 1, we endeavour to answer a review question “Is executive dysfunction a neuropsychological deficit which relates to anxiety in children with ASD?. Therefore, the focus is to set a scene on EF as a neuropsychological deficit which relates to anxiety.

The total score for each of the scores in the selected key criteria was double rated and indicated with *. The original score was retained in parenthesis (). All the key criteria are indicated in green. The domain total score after double rated score was added is indicated with **. The original domain total score is indicated in parentheses (). Kindly refer to Table 3.5 above.

3.5.1 Rationale for choosing the criteria

a. Key Criteria a: Was ASD diagnosis confirmed for the study?

This criteria is important for this study as autism exists within a continuum or spectrum. Furthermore, due to the considerable clinical variation and aetiological heterogeneity of ASD, determining behavioural phenotypes for precise diagnosis in young children is difficult (Wing et al., 2011). In addition, Lord et al. (2000) indicated that diagnostic instruments should be sensitive and specific; reliable and valid; simple and brief, and appropriate for all ages and ranges within the

autism spectrum. Following that, Falkmer et al., (2013), conducted a systematic review addressing the accuracy, reliability, validity and utility of reported diagnostic tools and assessments. They found that The Autism Diagnostic Interview-Revised (ADI-R) and Autism Diagnostic Observation Schedule (ADOS) stood out with the largest evidence base and highest sensitivity and specificity. The ADI-R and ADOS also revealed the level of accuracy very similar to the correct classification rates for the current 'gold standard' diagnostic procedure when used in combination of them.

b. Key Criteria b: Was EF measured using standardised, valid and reliable measures?

The review questions specifically looking at EF therefore it is critical to determine whether this construct was measured using a standardized, valid and reliable measure. Hill, 2004 found that the majority of studies looking at EF and autism recruited children and adolescents as a sample. However, to our knowledge, no EF measures have been validated for use with ASD. Critical in measuring this construct also, is the fact that EF is a multidimensional construct. Therefore, the test used should be able to measure several executive operations and also variance in individual skills (Ozonoff et al., 2005).

c. Key Criteria c: Do the results allow inferences to be made about the relationship between EF and anxiety in ASD specifically?

It is crucial for this review also to look at the relationship between EF and anxiety as being stated in the review questions. There are a lot of studies that tend to look at other construct together with EF in relation to other variables of interest. However, it is important that the result allows inferences to be made either directly or indirectly.

3.6 Summary and discussion of findings for review stage 1

a. Key Criteria a: Was ASD diagnosis confirmed for the study?

Greenaway and Howlin (2010) measured general diagnostic features in their sample using the Social Communication Questionnaire (SCQ; Berument et al. 1999; Rutter et al. 2003). Consideration of the evaluation criteria reveals that the study had weaknesses in relation to measures used to assess ASD features. Even though SCQ is also widely used for ASD diagnosis, but it is not considered as 'gold standard' diagnostic procedure.

In contrast, Hollocks et al. (2013), used the ADI-R, Autism Diagnostic Observation Schedule-Generic (ADOS-G) and also the SCQ to confirm ASD diagnoses in their sample. They are not only utilized a full clinical assessment for an ASD diagnosis using a combination of goal standard diagnostic procedure, but they used these in combination with SCQ in order to differentiate symptom severity.

Similarly, Lawson et al., 2014, utilized ADOS and ADI-R to confirm the ASD diagnosis in 70 participants in their study. However, this study used archival data with no specific range of date where the data was retrieved. It was not mentioned also specifically at what point that the ADOS and ADI-R was administered which leads to doubt about the validity of the diagnostic procedure.

Finally, the study by Zandt et al. (2009) did not mention specific diagnostic procedures (e.g. Interview, questionnaires, etc.) but mentioned that the children in their study were diagnosed by an experienced multidisciplinary assessment team consisting of paediatricians, a psychologist and speech pathologist in accordance with criteria in the Diagnostic and Statistical Manual of Mental Disorders-Fourth Edition-Text Revision (DSM-IV-TR; American Psychiatric Association: 2000). From clinical exposure obtained by Principal Researcher in Australia, it is not a practice to utilized ADOS and ADI-R in Australia. The diagnosis of ASD was confirmed through a structured interview by experts in the field and later on being discussed in multidisciplinary team meetings. This study obtained two points which indicated that diagnosis have been confirmed in this study, but not by use of a 'gold standard' diagnostic procedure.

b. Key Criteria b: Was EF measured using standardised, valid and reliable measures?

Greenaway and Howlin (2010) investigated whether cognitive inflexibility will relate to higher levels of dysfunctional and perfectionistic attitude as part of the overall aims in their study. They utilized the shorter version of WSCT (WSCT-64; Kongs et al, 2000) in this study. The standard score for perseverative errors was used. The WSCT-64 is considered as valid and reliable measure for shortening the administration time for most individuals while retaining the task requirements of the standard version. Normative, reliability, and validity data are derived from the same samples used in the standard WCST. The normative sample includes both adults (18 to 89 years of age) and children aged 6 to 17 years (Kongs et al, 2000). The use of WSCT-64 appears adequate in this study as the focus is only on cognitive flexibility, however, the authors did not provide evidence of validity and reliability of this test but provide the cited reference.

Hollocks et al., (2013) examined the relationship between multiple measures of EF and social cognition on severity of anxiety and depression. They employed 4 different types of EF measures, namely:

a. The opposite world task. Taken from the Test of everyday Attention for Children (TEA-Ch; Manly et al., 2001). Purported to measure interference inhibition.

b. Trail making (Reitan, 1958). Purported to measure attentional switching in this study.

c. The Digit Span task from Children Memory Scale (Cohen, 1997). The backward digit span was used purported to measure verbal working memory.

c. Card Sorting task, adapted from the WSCT (Grant and Berg, 1948) was used to measure cognitive set-shifting. The adapted child friendly version of WSCT (Hughes et al., 2009) was used.

This study purported to examine global EF deficits in relation to social cognition and anxiety rather than specific EF functions. The use of these 4 measures appears adequate but there are better selections available utilizing test batteries such as Delis-Kaplan Executive Function Scale (D-KEFS; Delis, 2001) and Developmental Neuropsychological Test-Version II (NEPSY-II; Korkman et al., 2007). In NEPSY-II, the Attention and Executive functioning subtest can be used to measure overall EF functioning. Furthermore, the batteries have standardized norms, reliability and validity. Furthermore, the NEPSY-II for example have guided interpretations when used with ASD children.

On the other hand, Lawson et al., (2014) used the BRIEF (Gioia et al., 2000), parent form in order to measure EF functions of flexibility/shifting and behavioural inhibition and evidence of reliability and validity was not provided in this study, only cited reference were reported.

Finally, Zandt et al., 2009 used a combination of measures of EF functions which encompassed:

a. The Verbal Fluency Task from A Developmental Neuropsychological Assessment (Korkman et al., 1998), purported to measure generativity or mental flexibility.
b. The Concept Generation Test–Child Version (CGT–CV: Jacobs et al., 2001), a measure of generativity or mental flexibility.
c. The Rey Complex Figure Test (Rey, 1941), used to assess planning and organizational skills.
d. The Walk, Don't Walk - subtest of the Test of Everyday Attention for Children (TEACh) (Manly et al., 1999) provides a measure of inhibition response and sustain attention.
e. The Behaviour Rating Inventory of Executive Functioning (BRIEF: Gioia et al., 2000), a parent rated questionnaire purported to assess executive functioning in everyday life covering behavioural regulation, and metacognition indices.

Similar to Hollocks et al., (2013), the use of these 5 measures appears adequate but there are better selections available utilizing test batteries such as Delis-Kaplan Executive Function Scale (D-KEFS; Delis, 2001) and Developmental

Neuropsychological Test-Version II (NEPSY-II; Korkman et al., 2007), with standardized norms, reliability and validity.

c. Key Criteria c: Do the results allow inferences to be made about the relationship between EF and anxiety in ASD specifically?

Using a sample of 41 ASD boys and 42 TD controls, Greenaway and Howlin (2010), explored dysfunctional attitude and perfectionism in relation to emotional symptoms (anxious and depressive symptoms). The author also endeavour to examine whether dysfunctional attitudes and perfectionism related to cognitive flexibility. Therefore, EF (cognitive flexibility) and anxiety are not key constructs for this study. The authors explored potential relationships between variables using correlational analyses and reported that the relationship between emotional and cognitive variables was weak in both ASD and TD. There are no aims or hypothesis was stated in terms of the relationship between cognitive flexibility and anxiety. Therefore, the finding is considered as indirect inferences made from the data. Furthermore, the data about this relationship were not provided making it difficult to draw any meaningful conclusions. Consideration of the key evaluation criteria reveals that the analysis and result only allow minimal/indirect inferences to be made about the relationship between EF and anxiety specifically.

On the other hand, Hollocks et al. (2013) used EF and anxiety as key construct, beside Social cognition and Depression in their study. They explored the association between these 4 constructs in 90 adolescents (mean age 15.5 years) with ASD. They utilized correlation and regression analyses as main analytic techniques. Based on these analyses they found that poorer executive functioning leads to greater anxiety in this samples. This study obtained two points which indicates that the result allow inferences to be made but very limited. The weakness of this analysis and findings lies on the measures used to assess anxiety. They used SDQ and PONS to assess both depression and anxiety, which given the issues with measurement may not actually represent this construct and therefore provides limited evidence with regard to this potential relationship.

Lawson et al. (2014), focused on whether flexibility in ASD and inhibition in ADHD mediate the associations between ASD/ADHD and anxiety/depression. EF and anxiety are among the main construct being studied in this research. The author employed ANOVA and Correlation analysis as main analytic technique. Results indicated that children with ASD have more problems with inflexibility, which is associated with more downstream comorbid anxiety/depression. Considering the key criteria c, two points was allocated to this study which indicates that the result allow inferences to be made but these are limited in terms of specific relationship between EF and anxiety. The weakness lies on the use of CBCL to measure anxiety as better selections of anxiety measures such as SCAS or CY-BOCS is available which have been commonly used in ASD research with better normative data, reliability and validity. Other than that the measure for EF (BRIEF), is a parent rated questionnaires which is limited to parent perspectives of observable behaviour. Furthermore, the absence of nonclinical control group, cross-sectional study design and the use of correlation analysis leads to causal conclusions cannot be drawn.

The final paper under review is Zandt et al. (2009) who compared EF in ASD and OCD children. They also explored the relationship between RRBs and EF in children with ASD and OCD. Their participants are 54 children with ASD, 17 children with OCD and 18 TD controls. The author employed ANOVA and Correlation analysis as their analytic technique in this study. Result showed that children with ASD perform poorly on task requiring multiple responses and EF was impaired in both ASD and OCD groups. Considering the evaluations criteria c, this paper was rated with full points (3) which indicated that the relationship between EF and anxiety was well addressed. The result also allows strong inferences being made about the relationship between these constructs specifically. The major strength of this study is that they have 2 clinical groups (ASD and OCD) and a control group (TD) which allow better generalizations of the result. Furthermore, they have utilized a standardized, valid and reliable measure on anxiety, the CY-BOCS, which is among commonly used anxiety measures in ASD research. In addition, they have also employed both the performance and questionnaires measures of EF which includes a few EF function tests and a parent rated questionnaires (the BRIEF). The combination of

individual performance and parent rated questionnaires has helped to reduce the bias in measuring the construct which can effect the inferences made from the results.

3.7 Overall summary for question 1: Was ASD diagnosis confirmed for the study?

This first review aimed to investigate the potential relationship between EF and anxiety in children with ASD. In particular the review endeavoured to answer the review questions: Is executive dysfunction, a neuropsychological deficit which relates to anxiety in children with ASD? A total of 4 studies met inclusion criteria for review and were critically evaluated against a methodological threat grid that was specifically developed for this review study. These studies were then synthesized using key criteria that have been identified. All the results suggest that there appears to be some emerging evidence of a link between executive dysfunction and anxiety in children with ASD, particularly with regard to cognitive inflexibility and anxiety. Zandt et al., (2009), report a specific association between EF and OCD, suggesting that this relationship may exist in the context of specific anxiety subtypes. Further investigation is needed to ascertain whether specific EF deficits relate to specific anxiety subtypes and whether there any potential causal relationship between them.

3.8 Question 2: Sensory Processing Dysfunctions and anxiety in children with ASD.

3.8.1 Method of Review

Similarly to question one, a mixed method was also being adopted in this review to obtain a fuller picture of sensory atypicalities and anxiety in children with ASD. Kindly refer to review stage 1 for detail descriptions.

3.8.2 Search strategy

a. Definition of concepts

The main terms were ASD and anxiety and sensory. Other detail descriptions of the concept of ASD used are similar with review stage 1. Kindly refer to the above.

b. Definition of keywords

Truncations (*) were employed to make sure that terms with multiple suffixes were captured in the search process. Table 3.5 below shows search terms utilised during database searches.

Table 3.5

Methodological Qualities of Studies

Concept	Search term
1. Anxiety	anxi* (anxiety/anxious)
2. Sensory	Sensory* (atypicalities/dysfunctions/modulation)
3. Autism Spectrum Disorder	Autis* (autistic/autism/autism spectrum disorder) Asperg*(Asperger Syndrome)

c. Application of Boolean Operators

During database searches, firstly all terms for anxiety were combined into one set using the Boolean operator “OR”. This was repeated for all search terms related to the concept of sensory processing and ASD. The anxiety concept was then combined with each of the 3 remaining concepts using the Boolean operators “AND”. In the OVID Medline, Embase and PsycINFO databases, the “Explode” function searches was used for an index term of “anxi*”, “sensory*”, “autis*” and “asperg*”. It was then automatically ORs with all of its narrower terms.

d. Limits of Search

Similar limits of search for study 1 was used. Kindly refer to review stage 1 for details.

e. Retrieval Sources

The following resources were searched utilising the search strategy outlined.

3.8.3 Electronic databases.

a. Stage 1

The search strategy involved systematic searching of several electronic databases outlined at review stage one. In WOK and Scopus, abstract and keyword search was used. In Embase, Medline and PsychINFO, database searches were carried using keywords. The following table summarize the search terms used in these three databases. In each of the databases, the search terms was mapped to subject headings which either can be “explode” or “focus”. Later on the selection was combined using default ‘OR’ to include all subheadings. This resulted a total of 832 hits which were exported to Endnote. Electronic databases searched and number of hits acquired are as per **Appendix C.**

3.8.4 Author search.

The author search was done based on author names that are prominent in the area of sensory processing and anxiety in ASD. Therefore, the following author’s names were searched using the online databases:

a. Ben-Sasson, A.
b. Green, S.
c. Pellicano, E.

This search has resulted in no additional papers.

3.8.5 Hand journal search.

Hand journal search was done on the following journals:

a. Journal of Autism and Developmental Disorders (Springer)

b. Autism Research (WILEY)

c. Autism (SAGE)

This has resulted with no additional papers.

3.8.6 Grey literature search.

Searches were also carried out in Google and Google Scholar. This has resulted one additional paper (Wigham et al., 2014).

3.8.7 Additional search strategies.

a. Author contact.

A number of authors were identified as key authors and contacted to ask for any unpublished papers. This has resulted in no additional number of papers.

Ben-Sasson, A.
Green, S.
Pellicano, E.

All the authors had replied that there is no unpublished papers or soon to be published papers in the area of sensory atypicalities and anxiety in children with ASD. This has resulted in no additional papers.

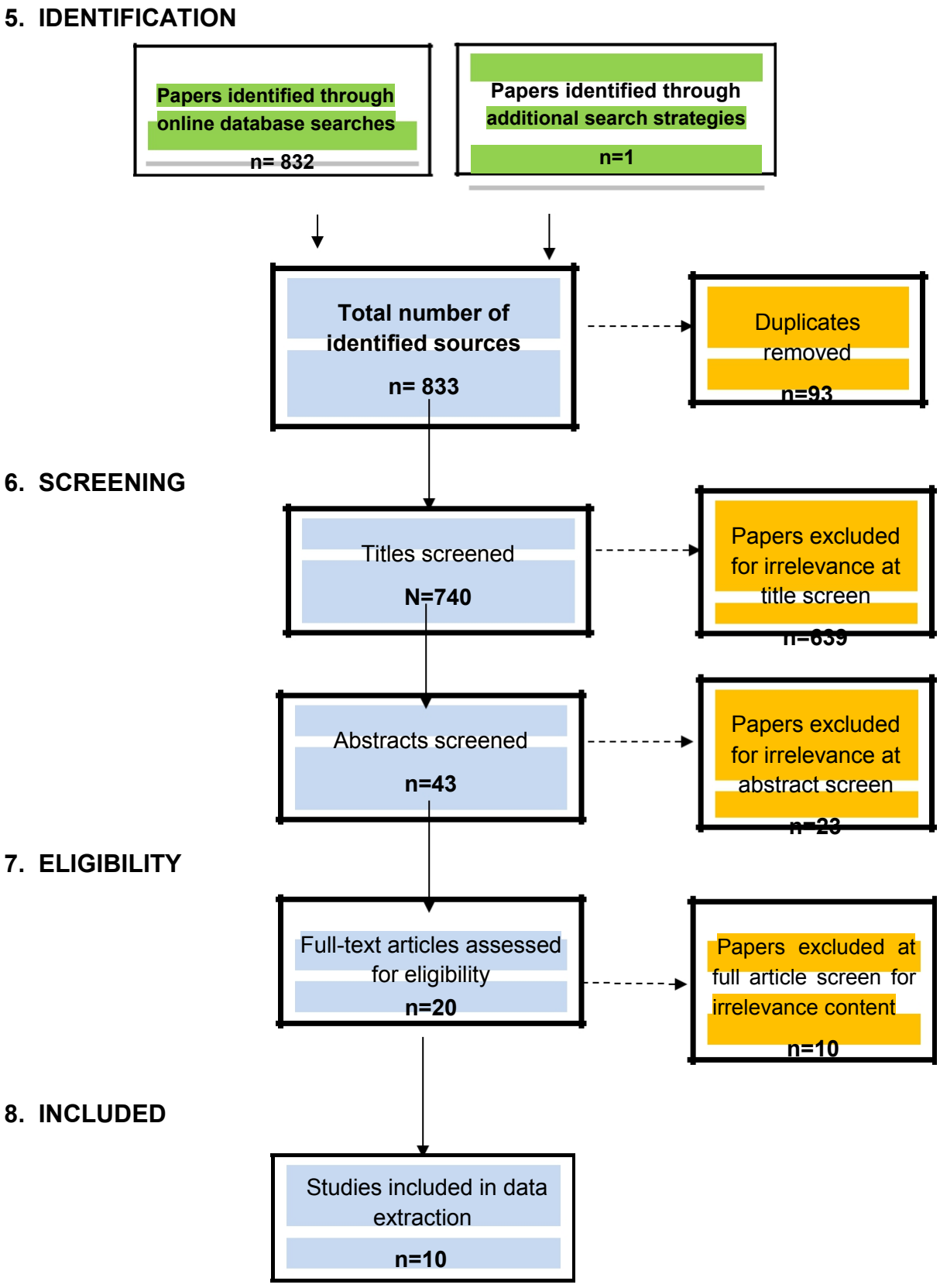
b. Cited references.

The references of relevant papers were examined to check for cited papers. This has resulted in no additional paper.

3.9 Screening and Selecting

The screening and selecting papers are similar with stage one. Kindly refer to review stage 1 for detail descriptions. Figure 3.2 shows the process of screening and filtering of papers at review stage 2.

Figure 3.2
Screening and filtering of papers for review stage 2



3.9.1 Journals

Selected studies came from the following journals:

1. Journal of Psychiatry and neuroscience - (1)
2. Journal of Abnormal Child Psychology - (1)
3. Journal of Autism and Developmental Disorder - (1)
4. The American Journal of Occupational Therapy - (2)
5. Australian Occupational Therapy Journal - (1)
6. American Academy of Child and Adolescent Psychiatry - (1)
7. Autism - (1)
8. Research in Autism Spectrum Disorders - (2)

3.10. Results

3.10.1 Summary of Identified Papers

Nine papers met the full inclusion criteria and the key information was extracted and is summarised in table 3.6. These papers were subsequently evaluated against the methodological threat grid that has been adapted for use in review stage 2. See table 3.7.

3.10.2 Populations studied.

Eight of the studies included ASD samples, one study included learning disability (LD) sample, and one study used PDD children as their sample. Two studies have included typically developing (TD) samples as controls. The sample represents children and adolescent and their mean age are within age inclusion criteria for this study.

3.11 Measures used

3.11.1 Measures of sensory processing

Measures of SP used are also varied. The majority of studies utilized parent version of SP questionnaires. There is one study who has utilized MRI in combination with questionnaire to measure SP. One of the studies did not utilize any measures, but gather information from interview with parents and teachers which later being interpreted and classified by Child Psychiatrist. Interestingly, there is one study which has utilized electrophysiological method in combination with questionnaire measures. This study used Electro-dermal Response measures (EDRs) and also Salivary Cortisol to measure sensory modulations. Each of the measures used was evaluated with regard to its strengths, weaknesses and utility, with this information being used to inform the potential threat criteria with regard to the measurement of SP dysfunctions (see **Appendix D**).

3.11.2 Measures of anxiety.

The measures used to assess anxiety are also varied. Most of the measures used are part of the overall emotional or behavioural assessments (e.g. CBCL; Achenbach & Edelbrock, 1981). Three studies utilized direct anxiety measures (Lidstone et al., 2014; Sullivan et al, 2014 & Wigham et al., 2014) which is commonly used in ASD research. Another study utilized STAIC (Tsuji et al., 2009) and RCMAS (Pfeifer et al., 2005 & Lane et al., 2012) and which are considered as appropriate measure for anxiety but not commonly used in ASD research. Nevertheless there is one study (Joostan and Bundy, 2010) which has employed the ABRS (Eifield and Tounge, 2002) and MARS: R (Joostan et al, 2009). Kindly refer to table 6 below for Summary of papers under review and details of the measures used in each studies.

Table 3.6

Summary of papers under review for stage 2

Paper	Aims/ Hypothesis	Participants	Measure of anxiety	Measure Of Sensory	Statistical Analyses	Result/ Conclusion
Green et al. (2013)	Aim: -to examine the functional neural correlates of SOR by comparing brain responses to sensory stimuli.	-25 HFA youth with ASD -25 TD matched controls -aged 8-17 (m=13.3; SD=2.29)	- CBCL (anxiety scale)	- MRI - SSP - The SenSOR inventory	-FSL Version 4.1.4 (for MRI data) -ANOVA - Correlation Analysis	-ASD participants displayed greater activation in primary sensory cortical areas as well as amygdala, hippocampus, and orbital-frontal cortex. -In both group, the level of activity in these areas was positively correlated with level of SOR severity as rated by parents, over and above behavioural ratings of anxiety.
Joostan & Bundy (2010)	Hypothesis: -Children with ID (with and without autism) have sensory processing	-52 participants, age range: 5-18 years	-The ABRS -MARS-R	- The SP - MARS-R	-t-tests	-Children with both ASD and ID, used more stereotypical behaviour to alleviate anxiety, were significantly more

	patterns that are different from those of children with typical development. -It is hypothesized also that children with autism and ID have SP patterns that are qualitatively different from those of children with intellectual disability alone, and poor SP might contribute to the anxiety of children with autism.	-23 assigned to group 1 (ID) (mean age=9.7) -29 assigned to group 2 (ID and ASD), mean age=9.5)				sensitive to sensation and more extreme avoidant than the children with ID alone. -Sensory sensitivities may contribute to anxiety and the behavioural disorganisation commonly seen in children with ASD.
Lane et al., (2012)	Aim: -To explore the relationship between SOR and anxiety in children with autism, ADHD and TD.	-archival data from two different studies. -no. of participants was not mentioned. -aged 6-10 years	-RCMAS	-The SP -The SenSOR -EDRs -Salivary Cortisol	-Path Analysis -Mplus program	-The magnitude of physiological responses to sensory challenge was a mediator variable between predictors (baseline arousal and attention) and outcomes (anxiety and physiological recovery). -Behavioural SOR was correlated with anxiety but not with physiological variables.

Lidstone et al. (2014)	Aim: -to explore how atypical reactions to sensory stimuli contribute to the relation between RRBs and anxiety in children with ASD.	Study 1: -Parents of 120 children with ASD -aged 2.5 to 17.9 Study 2: -49 parents of children with ASD in study 1 -aged 3.0 to 17.9	Study 2: -SCAS-P -PAS	Study 2: -The SP	Study 1: -Factor Analysis Study 2: -Correlation Analysis -Mediation Analysis	-The insistence on sameness factor was significantly associated with anxiety while the repetitive motor behaviours factor was not. -The relation between anxiety and insistence on sameness was mediated by sensory avoiding and to a lesser extent by sensory sensitivity.
Mazurek et al. (2014)	Aim: -To examine the one-year course of parent-reported abdominal pain in children with ASD. -To determine whether anxiety and SOR contribute to the onset or remission of abdominal pain.	-225 children and adolescents with ASD -aged 2 to 17 years	-CBCL	-SSP; Sensory Over-responsivity subtest	-ANOVA -Correlation Analysis -Regression Analysis	-Anxiety, SOR, and chronic abdominal pain were associated at baseline. -SOR significantly predicted new onset pain, but neither anxiety nor SOR were predictors of pain remission.
Mazurek et al.	Aim:	-2,973 children with ASD	-CBCL	-SSP;	-ANOVA	-Children with each type of GI problem had significantly higher

(2013)	-To examine the relations among SOR, anxiety, and GI problems within a large, well-characterized sample of children and adolescents with ASD. Hypothesis: - Sensory over-responsivity will be associated with increased levels of anxiety. - Children with GI problems will show higher rates of anxiety than children without GI problems. - Children with GI problems will show greater difficulties with sensory over-responsivity than children without GI problems. - Sensory over-responsivity and anxiety will independently contribute to the prediction of GI problems.	-ages 2–17 years		Sensory Over-responsivity subtest	- Correlation Analysis - Regression Analysis	rates of both anxiety and sensory over-responsivity. -Sensory over-responsivity and anxiety were highly associated, and each provided unique contributions to the prediction of chronic GI problems in logistic regression analyses.
Pfeifer et al. (2005)	Aim: -To determine if there were significant relationships between dysfunction in	-Parents of 50 children and adolescents	-RCMAS	-SSP - Adolescent/	-ANOVA	-There were significantly strong positive correlations between

	sensory modulation, affective disorders, and adaptive behaviours Hypothesis: -There will be a positive relationship between sensory defensiveness and anxiety. -There will be a positive relationship between sensory hyposensitivity and symptoms of depression. -There will be a negative relationship between the levels of anxiety and depressive symptoms and overall adaptive behaviours. -There will be a negative relationship between levels of hyper and hyposensitivity and overall adaptive behavioural functioning.	-aged between 6 and 17 years -diagnosed with Asperger's disorder		Adult Sensory Profile	-Correlation Analysis	sensory defensiveness and anxiety.
Sullivan et al. (2014)	Aim: -To investigate into how the presence of migraine headaches relates to sensory	-Parents of 81 children with ASD	-SCAS; The Generalized Anxiety Subscale	-SSP; The SOR Scale	-Mann-Whitney U tests	-Children with ASD who experienced migraine headaches showed greater sensory hyper-reactivity and

	hyper-reactivity and anxiety levels in children with ASD. Hypothesis: -Autistic children who are reported to present with migraine headaches will also show greater sensory hyper-reactivity than those without migraines.	-Aged 7–17 years (mean = 10.3; SD = 2.6 years).			-Correlation Analysis	anxiety symptomatology than those without migraines. -Sensory hyper-reactivity and anxiety symptomatology were correlated.
Tsuji et al. (2009)	Aim: -To clarify the relationship of hyper-sensitivity to anxiety, depression and other psychopathology in children with PDD. Hypothesis: -Hyper-sensitivity had a greater impact on PDD patients' daily lives than hypo-sensitivity.	- 64 HFPDD children - (HG; n=43, non-HG; n=21)	-CBCL -STAIC	-No standardised measures used. -Interview with parents and teachers -Based on the info obtained 2 child psychiatrist classified the HG and non-HG group.	-Mann-Whitney U test	-The HG group had significantly higher scores than the non-HG group in Total, Internalizing, and Somatic complaints on the CBCL. -On STAIC, the mean sore of Total Score, State Score and Trait Score in the HG group tended to be higher than in the non-HGgroup,butthe difference was not significant.

Wigham et al. (2014)	Aim: - To determine pathways between sensory abnormalities and RRBs, and the role anxiety and IU may have. Hypotheses: - SUR would predict RMBs and insistence on sameness behaviours directly, without a mediating influence of anxiety or IU. - SOR would predict RMBs directly. - SOR would predict ISBs and anxiety would mediate this relationship.	- 53 children with ASD - 47 boys, 6 girls - mean age of 12.49 years (SD = 2.3 years; range 8–16)	- SCAS-P	-The SSP	- Correlation Analysis -t-test - Mediation model using PROCESS	- SUR and SOR were significantly associated RMBs and ISBs. - The relationships significantly mediated by IU and anxiety.

Key: SOR – Sensory Over-responsivity; **HFA** – High Functioning Autism; **ASD** – Autism Spectrum Disorder; **TD** – Typically Developing; **ID** – Intellectual Disability; **CBCL** – Child Behaviour Checklist; **MRI** – Magnetic Resonance Imaging; **SenSOR** – The Sensory Over-responsiveness Inventory; **ABRS** – Anxious Behaviour Rating Scale; **MARS-R** – The Motivation Assessment Scale-Revised; **RCMAS** – Revised Children's Manifest Anxiety Scale; **The SP** – The Sensory Profile; **EDRs** - Electrodermal Response Measures; **RRBs** – Restricted, Repetitive Behaviours; **SCAS-P** – Spence Children's Anxiety Scale-Parent Version; **PAS** – Preschool Anxiety Scale; **SSP** – Short Sensory Profile; **ANOVA** – Analysis of Variance; **GI** – Gastrointestinal; **PDD** – Pervasive Developmental Disorders; **STAIC** – State-trait Anxiety Inventory for Children; **HG** – Hypersensitivity Group; **Non-HG** – Non-Hypersensitivity Group; **IU** – Intolerance of Uncertainty; **SUR** – Sensory Under Responsivity; **RMBs** – Repetitive Motor Behaviours; **ISBs** – Insistence on Sameness Behaviours; **PROCESS** – A computational procedure for SPSS and SAS that implements moderation or mediation analysis as well as their combination in an integrated conditional process model.

3.12 Methodological qualities of studies for review stage 2

Similar with question one, the differences and similarities with regard to design, samples, measures and results were identified after the final papers were read. These papers were then evaluated in order to highlight their strengths and weaknesses. This is a deductive process in order to identify which papers are the most usefully interpreted with regard to the review questions.

In order to perform this, a methodological grid was developed. The development of the grid was guided by a number of existing grids, as well as previous reviews and relevant literature in the area of ASD. In addition, a meta-analysis study of Sensory modulation system in ASD (Ben-Sasson et al., 2009) and also a systematic review on sensory abnormalities in ASD (Hazen et al., 2014) were also consulted. The Potential Threat Scoring Criteria are as per appendix D and the Methodological qualities evaluation for review stage two are as per table 3.7.

Table 3.7

Methodological Qualities of Studies for review stage 2

Domain	Criterion	*Green et al. (2013)*	*Joostan & Bundy (2010)*	*Lane et al. (2012)*	*Lidstone et al. (2014)*	*Mazurek et al. (2014)*	*Mazurek et al. (2013)*	*Pfeifer et al. (2005)*	*Sullivan et al. (2014)*	*Tsuji et al. (2009)*	*Wigham et al. (2014)*
INTRODUCTION	Do the definition and concept of sensory atypicalities were being clearly stated?	2*	3*	3*	1	2*	3*	2*	1	2*	2*
	Are the aims, hypotheses and objectives clearly described for the constructs being studied (SP and anxiety)?	3	3	1	2	3	3	3	2	2	3
Domain A Total Score/6		5	6	4	3	5	6	5	3	4	5
METHODOLOGY	Does the recruitment methodology evidence an attempt to gain a sample that is representative of the study population?	3	1	1	2	2	2	2	1	2	2
PARTICIPANTS	Are the inclusion and exclusion criteria justified?	1	1	2	2	1	1	0	2	2	1

DESIGN	Are sample characteristics described (age, gender, ASD subtypes, Comorbidities, medication use and demographic variables)?	2	1	2	2	2	1	2	2	1	1
	Was ASD diagnosis confirmed for the study?	3*	1	1	2*	3*	3*	1	2*	2*	1
	Was level of cognitive functioning of participants assessed?	3	2	3	1	3	3	1	1	3	3
	Are the participants appropriate to answer the research question?	3	2	2	3	3	3	2	2	2	2
	Was the design appropriate for the study question? (e.g., for knowledge level about this issue, outcomes, ethical issues, etc.)	2	2	3	2	2	2	2	2	2	2
	Any biases that may have been operating have been specified and the direction of their influence on the results were mentioned?	2	1	2	3	3	3	2	3	2	2
	Was an anxiety measured using	1	1	3	1	1	1	1	1	1	2

MEASURES	standardized, valid and reliable measures?										
	Were the measures of anxiety used appropriate for ASD population?	1	0	1	1	1	1	1	1	1	1
	Was SP measured using standardised, valid and reliable measures?	1	2*	3*	3*	1	1	2*	1	0	2*
	Were the measures of SP used are appropriate for use with an ASD population?	1	1	1	1	1	1	1	1	0	1
	Based on the above, how well was assessment done to reduce bias and to gain accurate outcome measures?	0	0	2	2	0	0	1	1	0	0
Domain B total score/39		23	15	26	23	22	21	16	19	18	20
RESULTS/ ANALYSIS	Is the statistical analysis appropriate to the design?	3	2	2	2	3	3	2	2	2	3
	Are descriptive statistics provided?	2	1	1	2	3	3	3	2	2	2
	Is appropriate supplementary	0	1	0	1	2	2	1	2	0	0

	information provided (i.e. effect sizes, power)										
	Do the results allow inferences to be made about the relationship between SP and anxiety in ASD specifically?	3*	3*	3*	2*	2*	2*	2*	2*	2*	2*
Domain C total score/12		8	7	6	8	10	10	8	8	6	7
DISCUSSION	Do the conclusions follow adequately from the results?	3	2	3	2	0	0	0	2	2	3
	Are limitations acknowledged?	2	1	2	3	3	3	3	3	2	2
Domain D total score/6		5	3	5	5	3	3	3	5	5	5

*Indicates scores/papers included in key criteria after triage

3.13 Key criteria of sensitivity in review stage 2

Four key criteria of sensitivity for review study were identified based on the literature on SP and anxiety. Therefore, the following section should be read in conjunction with table 7 above (Methodological Qualities of studies for review 2). The key criteria are:

a. Do the definition and concept of sensory atypicalities were being defined?

b. Was ASD diagnosis confirmed for the study?

b. Was SP measured using standardised, valid and reliable measures?

c. Do the results allow inferences to be made about the relationship between SP and anxiety in ASD specifically?

The 'triage system' was applied in the criteria, whereby papers that obtained scores of 2 and above across all of these key criteria were included in discussion of the results. Papers which had a lower score were deemed to be of insufficient rigour and not taken forward for discussion. The strengths and weaknesses of the papers which scored 2 or above on the key domains are highlighted in the discussion. The selected scores was marked with asterisk (*). All the key criteria are indicated in green and the domain total score are indicated in yellow. Kindly refer to Table 3.7 above.

3.13.1 Rationale for choosing the key criteria.

a. Key criteria a: Do the definition and concept of sensory atypicalities were being stated?

The description of sensory atypicalities in ASD is not a clear and straightforward to understand at the moment. A lot of understanding about sensory abnormalities in autism are based on the Sensory Modulation Disorders (SMDs; Miller et al., 2005), which is a subtype of Sensory Processing Disorders (SPDs). SMDs are classified into three type; a) sensory over-responsivity b) sensory under-responsivity and c) sensory seeking. This classification is based on Dunn's (1997) model. One of the recent model, Bayesian model suggest that sensory

atypicalities exist at the level of internal, working models of the world 'priors', in Bayesian terms (Pelicano and Burr, 2012). These lead to characteristic differences in autistic sensation and perception. According to this model, it is not sensory processing itself that is different in autism, but the interpretation of sensory input to yield percepts. This key criteria is important as the accurate definition of SP construct being studied will determine the overall direction of the research.

b. Key criteria b: Was ASD diagnosis confirmed for the study?

Kindly refer to rationale for review stage 1.

c. Key criteria c: Was SP measured using standardised, valid and reliable measures?

One of the most commonly used instruments in both research and clinical settings is the Sensory Profile (SP; Dunn, 1999) which is designed for children aged 3 to 10 years of age. One of the advantages of this instrument is ease of use, as it consists of a straightforward questionaires that can be rated by parents. Perhaps the gold standard of standardized assessments for sensory dysfunction is the Sensory Integration and Praxis Test (SIPT; Ayers, 1989). This tool provides a comprehensive assessment of sensory functioning for children ages 4 years to 8 years, 11 months old. The SIPT involves direct observation of a child's behaviour rather than relying on questionnaires. Robertson (2012) found a disparity between the results of self or parent report studies and behavioural studies (Robertson, 2012). Studies which utilized self or parent report shows that those with ASD report clear, consistent differences in their sensory experiences (Baranek et al., 2006; Crane et al., 2009; Leekam et al., 2007), whereas the findings in the behavioural field are complex to interpret. Nevertheless, there are variations in SP measures available including short version of SP (Short sensory profile: SSP; Dunn, 1999), but none of these has a published standardized norms for children with ASD.

a. Key criteria d: Do the results allow inferences to be made about the relationship between SP and anxiety in ASD specifically?

It is also aimed that the result will allow strong inference to be made about the relationship between SP and anxiety in ASD specifically. A meta-analytic study by Ben-Sasson et al. (2009), found a significant high difference between ASD and TD in the presence or frequency of sensory symptoms, with the greatest difference in under-responsivity, followed by over-responsivity and sensation seeking. Sensory processing and anxiety do hold distinct clinical definitions, studying their relationship however still have a lot of challenges (Ben-Sasson et al., 2007). The aspects of anxiety and sensory-processing difficulties that contributes to theoretical comparisons also create difficulties when attempting to distinguish these two constructs. The behaviours characteristic (e.g., avoidance and dysregulation) overlap, and clinical interpretations are biased by the orientation of the clinician (*ibid*). Anxiety and sensory-processing also was found to share similar physiological pathways (Green and Ben-Sasson, 2010). Communication impairments in certain cases prevent accurate self-report of symptoms. Furthermore, the behavioural overlaps in ASD phenomenology, anxiety, and sensory processing are difficult to differentiate on when being measured using questionnaires.

3.14 Discussion of findings for review stage two

3.14.1 Key criteria a: Do the definition and concept of sensory atypicalities were being stated?

Three papers obtained score of 3 for this criteria (Joostan & Bundy, 2010; Lane et al., 2012 and Mazurek et al., 2013), and two papers obtained score of 2 (Mazurek et al., 2014; Pfeifer et al., 2005 and Tsuji et al., 2009).

Joostan and Bundy (2009), utilized sensory processing model by Dunn (1999, 2006) to describe the overall framework of SP dysfunctions. They were particularly interested in the idea by Dunn (1999) that behaviour associated with SP could be described using a four quadrant model: ’seeking’, ‘registration’, ‘sensitivity’ and ‘avoidance’. Lane et al. (2012) described atypical sensory

processing in ASD in the form of sensory under-responsivity, sensory seeking/avoiding and sensory sensitivity. Sensory under-responsivity has been reported common in ASD, followed by sensory seeking (Ben-Sasson et al., 2009). Mazurek et al., 2013, grouped SP domains into three separate group: 1) sensory over-responsivity, 2) sensory under-responsivity, and 3) sensory seeking (Dunn, 1997; Miller et al., 2007). The author has a particular interest with the effect of sensory atypicalities on emotional and physical health. They found that sensory over-responsivity has a particular relevance with these aspects of health in comparison with others.

In the studies which have obtained scores of 2, they did not provide clear definitions of the subtype of SP that they were interested in. Mazurek et al., 2014 for instance were interested in the relationship between SOR and GI problems. They defined SOR as distress, avoidance, or hypervigilance in response to particular sensory stimuli (Miller et al., 2007 and Reynolds & Lane, 2008). Similarly, Pfeifer et al. (2005) were interested with SMDs and described that children with ASD either under or over-respond to sensory input from the body or environment (Hanft, Miller, & Lane, 2000). Specifically, they focussed on sensory defensiveness which is a behavioural responses associated with hypersensitivity or over-responsiveness. The authors defined sensory defensiveness as a fight or flight reaction to the same sensory stimuli by others considered non-noxious (Bundy, Lane, & Murray, 2002). Finally, Wigham et al. (2014) focused on two types of sensory input; the SOR and SUR (Miller et al. 2007). They relate these sensory input with anxiety, RRBs and IU.

3.14.2 Key criteria b: Was ASD diagnosis confirmed for the study?

Three studies obtained a full score for this criteria: Green et al., (2013), Mazurek et al, (2014) and Mazurek et al., (2013). Using a sample of 25 youth with ASD and TD, Green et al., (2013) confirmed the diagnosis of ASD group using a combination of ADI-R and ADOS. Mazurek et al. (2014) using ADOS for confirmation of an ASD diagnosis. Even though this study is not using ADOS in combination of ADI-R, it is still considered as adequate as part of the ‘gold

standard' diagnostic procedure. Similarly, in another study by Mazurek et al. (2013), they also used ADOS for diagnostic confirmation in a sample of 2,973 children with ASD. Both of these studies (Mazurek et al, 2014 and Mazurek et al., 2013) recruited their participants from Autism Treatment Network (ATN), a North American multi-site network of 17 autism centers across United States and Canada. However, it is unknown whether these two studies administered the ADOS at the point of entry to the study as part of the eligibility or it was administered as part of the diagnosis when they joined the ATN.

There are three papers that obtained a scores of 2 for this criteria. Those papers are: Lidstone et al., 2013, Sullivan et al., 2014 and Tsuji et al., 2009. Lidstone et al., 2013 did not use specific diagnostic measures to diagnose the participants in this study. The assessment for diagnosis confirmation was done by a multidisciplinary team according to the DSM-IV-TR (American Psychiatric Association, 1994) and ICD -10 (World Health Organization, 1992) criteria. However, it was not mentioned in the paper the expert disciplines that comprised the multidisciplinary team, whether the assessment was done in a form of interview or behaviour observation, and also the informants (e.g. parents or teachers). Sullivan et al., 2014 utilized Autism Quotient (AQ: Allison et al., 2012) screener to confirm the diagnosis of 81 children with ASD. In another study, Tsuji et al., 2009, confirmed the eligibility of their participants to the study by:

a. Interviewing parents about their children's developmental history and any history of autistic behaviour that their children exhibited since infancy via a questionnaires.
b. Obtaining information from teachers via questionnaires about PDD.
c. More than two child psychiatrists carried out the interview
d. Observing the child's clinical course for more than three months.

However, the name of questionnaires about PDD was not mentioned in this paper. Therefore, the reliability and validity of the questionnaire is unknown. This study was conducted in Japan and it is well aware also that the administration of ADI-R and ADOS are not a standard of practice in certain country, including Japan. Therefore, it is unknown also whether these two measures are available in Japan. At this point also, it is unable to certain whether the above diagnostic

procedure is a standard of practice in Japan. Due to these, this study obtained two points in this criteria, which indicates diagnosis have been confirmed for this study, but not by use of a gold-standard tool.

3.14.3 Key criteria c: Was SP measured using standardised, valid and reliable measures?

In this criteria, two studies obtained full score of 3. Firstly, Lane et al. (2012) who have used a standardised measure for SP which is the Sensory Profile (SP; Dunn, 1999) and the Sensory Over-responsiveness Inventory (SenSOR; Schoen, Miller, & Green, 2008). Furthermore, sufficient details (reliability and validity), were provided in this study. Another paper by Lidstone et al. (2013) utilized the Sensory Profile (SP; Dunn, 1999) as well. Preliminary analysis in this study provided adequate discriminant validity and reliability.

As for papers that obtained scores or two on this criteria, they represent studies that used standardized measures and evidence of good psychometric properties was provided in their study but not in sufficient details. Joostan and Bundy (2010), utilized the SP to measure the four quadrant model of SP (Dunn, 1999). In this paper, they just reported the internal reliability of the SP using Cronbach's
α ranged from 0.47 to 0.91 (Dunn, 2006). In addition, the authors also used the Motivation Assessment Scale: Revised (MAS: R; Joostan et al., 2009). The MARS: R has an intrinsic and extrinsic motivators construct which consists items representing sensory and anxiety. The MARS: R, however is not a commonly used measures in the field of ASD. Furthermore, the normative data, reliability and reliability data was not provided in this study. Nevertheless, this paper is still obtained two scores due to the SP as the main measure of SP in this study.

Another study by Pfeifer et al. (2014) employed the SP and the Adolescent/Adult Sensory Profile (Brown & Dunn, 2002). For the SP, both convergent and discriminant validity were established by comparing the Sensory Profile to the School Function Assessment (SFA) (Dunn, 1999). Cronbach's α, calculated to determine internal consistency for each factor, varied for each factor between .72 to .92 (Dunn, 1999). On the Adolescent/Adult Sensory Profile Cronbach's α was

calculated to determine internal consistency coefficients that ranged from .646 to .748 in the four quadrants for the adolescent population. Lastly, a study by Wigham et al., 2014 who have utilized Short Sensory Profile (SSP; McIntosh et al. 1999). They have calculated the Cronbach's α for both SOR and SUR, SOR (α = .88) and SUR (α = .82).

3.14.4 Key criteria d: Do the results allow inferences to be made about the relationship between SP and anxiety in ASD specifically?

Generally, all papers under review allows a certain degree of inference to be made in terms of the relationship between SP and anxiety. The differences between them relate it whether it is possible to generate inferences directly or indirectly. This is very much depending on whether SP and anxiety are being studied as a key or secondary construct.

When assessing against the evaluation grid, three studies obtained score of 3 in this criteria. Firstly, Green et al. (2013), examined the functional neural correlates of SOR by comparing brain responses to sensory stimuli in youth with and without ASD. They hypothesized that youth with ASD will have greater activation in areas related to SP (thalamus and primary auditory and visual cortices) as well as areas related to anxiety (amygdala and hippocampus). Results indicate that ASD participants displayed greater activation in primary sensory cortical areas as well as the amygdala, hippocampus, and orbital-frontal cortex. In both groups, the level of activity in these areas was positively correlated with the level of SOR severity as rated by parents, over and above behavioural ratings of anxiety. However, higher amygdala activity was found co-occurring with higher Prefrontal Cortex (PFC) activation in the ASD group, which may reflect an immature or dysfunctional regulatory system. It is possible too that the PFC is inhibiting the amygdala, and the amygdala activation in the ASD group would be even stronger without modulation by the PFC. However, this conclusion could possibly reflect a more immature connectivity pattern in the ASD group.

Another study by Joostan and Bundy (2010), explored the relationship between SP, stereotyped behaviours and anxiety in children with ASD and ID and with ID alone. They hypothesized that children with autism and ID will have SP patterns

that are qualitatively different from those of children with intellectual disability alone, and poor SP might contribute to the anxiety of children with autism. They found that sensory sensitivities may contribute to anxiety and the behavioural disorganisation commonly seen in children with ASD. Given that, this study however utilized a fairly small sample size (29; ASD and ID, 23; with ID alone) and recruited from clinical settings which is not representing children with these diagnoses in the overall population.

Finally, the paper by Lane et al. (2012), explored the relationship between SOR and anxiety in children with ASD, ADHD and TD. They utilized both physiological and behavioural measures of SOR and anxiety in this study. Path analysis (Wright, 1921) was employed to describe the relationship between the variables. Results indicate that parent-reported SOR was strongly linked with measure of generalized anxiety, the RCMAS Total anxiety score. They concluded that the behavioural SOR was correlated with anxiety but not with physiological variable. However, the RCMAS was administered by the child but was read aloud by parents, resulting in much of parents' perception of anxiety rather than child's perception. Even though child's perception of SOR was not adequately measure but the physiological measure of child's tonic arousal and attention are related to anxiety.

Based on the assessment of the methodological threats, there are seven papers which were scored 2. The first paper is Lidstone et al., 2014, who explored how atypical reactions to sensory stimuli contribute to the relation between RRBs and anxiety in children with ASD. Correlational analysis shows that anxiety was associated with sensory sensitivity, sensation avoiding and low registration, but not with sensation seeking. However, the sample is small and has more male than female (45:4). Furthermore, they utilized all questionnaires measures without convergent validity with other measures or parent rated questionnaires.

Mazurek et al. (2014) examined the associations between parent-reported SOR, anxiety and chronic abdominal pain. Anxiety was found negatively correlated with SOR. Children with chronic abdominal pain had significantly greater anxiety and significantly lower SOR score.

Mazurek et al. (2013) studied the relationship between anxiety, SOR and chronic GI problems. Using a large sample of 2,973 children they found a statistically significant correlation found between SOR score and CBCL anxiety problem T-Score. The major strength of this study is utilizing a large sample size and it is among the first studies to explore GI problems, anxiety and SOR in ASD. Despite this, there are some limitations in terms of anxiety measures. This study and also Mazurek et al. (2014) have utilized anxiety problems T-Score in CBCL (Achenbach & Rescorla, 2001) to measure anxiety in their samples. Indeed, CBCL was found to have good sensitivity but low specificity for detecting co-occurring disorders in ASD (Pandolfi et al, 2012). However, other anxiety measures, The Spence Children's Anxiety Scale (SCAS), its revised version - the Revised Children's Anxiety and Depression Scale (RCMAS), and also the Screen for Child Anxiety Related Emotional Disorders (SCARED) was found robust in their measurement properties in measuring anxiety in children with ASD (Wigham & McConacchie, 2013).

Pfeifer et al. (2005) determined if there were significant relationships between dysfunction in sensory modulation, affective disorders, and adaptive behaviours in children and adolescents with ASD between 6 and 17 years of age. They hypothesized that there will be a positive relationship between sensory defensiveness and anxiety. Results show a significant relationship between anxiety and both of the components of sensory hypersensitivity, sensory sensitivity ($r = .443$, $p = .001$) and sensory avoiding ($r = 467$, $p = .001$). The main limitation of this study is the use of a volunteer convenience sample and the sample represented only one geographical region and race. Over 80% of the parents reported that their child received occupational therapy services while many also reported that their child received other services. Furthermore, approximately 74% of the children and adolescents were on medications which may have impacts on the strength of the relationships within the study.

Sullivan et al. (2014) investigated how the presence of migraine headaches relates to sensory hyperreactivity and anxiety levels in children with ASD. Anxiety scores were positively correlated with total SOR scores, as well as with olfactory and movement reactivity. The main strength of this paper is that it is the first study that illustrate a link between migraine and SOR in ASD. It is also fortified

findings of other authors in terms of link between SOR and anxiety (e.g. Green and Ben-Sasson, 2010). However, this is a pilot investigation with small sample size, over-representation of SPDs (53%) and the high comorbidity with ADHD (46%). In addition, no assessment of cognitive functioning and confirmation of ASD diagnosis was made. Furthermore, all assessments were done online which may introduce bias.

Using a sample of PDD children, Tsuji et al. (2009), who have investigated the relationship of hypersensitivity with anxiety, depression and other psychopathology in this sample. They found that on STAIC, the mean total Score, state score and trait score in the HG tended to be higher than in the non-HG, but the difference was not significant. This is the only study under review which indicates no relationship between SP and anxiety. This is the first study in Japan, which in different cultural background which also fortified finding of other authors (e.g. Green and Ben-Sasson, 2010) and uniquely using sample of PDD children. Despite this strength, there are a few limitations which need to be addressed. The sample is representing clinical population rather than general population of children with PDD. In addition, there is no measures used to examine hypersensitivity and the data was based on interview with parents, child and teachers. Later on two child psychiatrists classified the sample into HG and non-HG. Therefore, the reliability and validity of the hypersensitivity criteria was not established.

The final paper is by Wigham et al. (2014), who have explored the possible pathways between sensory abnormalities and RRBs, and the role anxiety and intolerance of uncertainty (IU) in a group of 53 children with ASD. The authors found that SUR and SOR were significantly associated with RMBs and ISBs. The relationships were significantly mediated by IU and anxiety. This study has a strength of using the dual site study design (UK and US) but it can also make the study potentially introduce confounds. Other limitations include small sample size, measures administered to informant which may introduce bias, and cannot generalize to children with ASD. Furthermore the SUR and SOR has been treated as distinct constructs in this study, whereby in reality they can both occur in the same individual.

3.15 Summary of findings for review stage two

This second review aimed to investigate the potential relationship between SP atypicalities and anxiety in children with ASD. In particular the review endeavoured to answer the review questions: Are sensory atypicalities related to anxiety in children with ASD? A total of 10 studies met inclusion criteria for review and were critically evaluated against a methodological threat grid that was specifically developed for the review. These studies were then synthesized using 'triage system' based on key criteria that have been identified. All the results suggest that there appears to be an evidence of a link between SP atypicalities and anxiety in children with ASD, particularly with regard to SOR and anxiety.

3.16 Overall discussions

This aim of this chapter was to review, synthesize and critically evaluate the empirical evidence pertaining to the influence of EF and SP atypicalities on anxiety in children with ASD. Specifically, the study aspired to answer the following review questions: a) Is executive dysfunction a neuropsychological deficit, which relates to anxiety in children with ASD? B) Are sensory atypicalities associated with anxiety in children with ASD?.

3.16.1 Issues across the Field

In reviewing these studies, a number of key issues has been identified and warrant further discussion. The most pertinent issues, which is a key theme across both reviews relates to sampling, confirmation of ASD diagnosis and measurement issues in ASD diagnosis and constructs being studied.

Confirmation of ASD diagnosis at the point of entry to study is also critical due to considerable clinical variation and aetiological heterogeneity of ASD (Wing et al., 2011). Very few of the papers under review utilized the ADI-R and ADOS at the point of entry to the study. There are some studies who have utilized the gold standard diagnostic procedures but did not specify when the procedure was done

and some studies have used the previously administered diagnostic procedure but did not specify when and type of measurement was used.

In terms of measurement, there are issues related to the validity and reliability of measures purported to assess EF and SP. Very few studies calculated and reported the Cronbach's α values in the measures used in their study. In review one, most studies utilized a combination of wide range of EF function test rather than test batteries which have a more standardized norms, reliability and validity. In terms of SP studies most of the papers utilized parent rated questionnaires which is more of parents' perception of SP rather than the child's perception. Furthermore, the use of questionnaires in measuring SP rather than combined with behaviour In Vivo will pose a bias to the results. Other than that, most studies measured both of sensory input (SOR and SUR) as distinct construct, which in fact, both of the sensory abnormalities may exist within the same individual. In terms of anxiety measures, most of the study utilized appropriate anxiety measures but most of them utilized parents' report of anxiety which may introduce bias. Furthermore, they are also not developed or standardised for children with ASD. Furthermore research indicated that children with high functioning ASD are likely to under-report anxiety symptoms, due to difficulty in identifying their own emotions as well as others' (White et al, 2012). Therefore the use of a combination of child's and parents' perspectives is likely to give a more rounded picture.

In terms of statistical analysis, most of the papers have utilized appropriate statistical analysis, however, very few papers provides supplementary information such as effect size and observed power which is quite hard to estimate the level of inferences can be drawn from the data. There is also potential confounds associated with testing, for example the impact of anxiety and concentration (particularly EF measures). Furthermore, there are no appropriate measures was reported in terms of appropriate procedure made to reduce confounding in these studies.

3.16.2 Clinical Implications

This systematic review guides new directions for clinical practice among children with ASD who presented with EF, SP and anxiety features. In clinical work, the

assessment for EF should incorporate both child performance and parents' report of EF to gain fuller symptoms of individual child.

It is well recognized also that the best-known intervention for SP abnormalities in ASD involve an occupational therapy program that is specifically tailored to the needs of the individualized children with ASD. These may include sensory integration therapy, a sensory diet, and environmental modifications (Hazen et al, 2014). Given the link between SP abnormalities and anxiety, the treatment should integrate the psychotherapy components. Therefore, greater efforts should be made to train psychiatrists, psychologists, occupational therapists and other mental health professionals working with the ASD population to evaluate patients for sensory as well as anxiety symptoms. Research showed that occupational therapists tend to rate similar items as sensory over-responsive, while psychologists diagnosed with a general anxiety disorder (Ben-Sasson et al., 2007). The overlap in judgments of SOR and anxiety provide an evidence that these constructs in part reflect different professionals' perspectives upon behaviours. In addition the ability to take an effective history of sensory symptoms will become essential to making an accurate diagnosis of ASD under the revised DSM-5 criteria. Therefore, it is essential to train clinicians to better understand their patients' experience and enabling them to frame better treatment strategies for children with ASD.

3.16.3 Limitation of Current Reviews

All articles in this study were accessed only in English language due to lack of translation resources. Data extraction was done only by the Principal Investigator, which may prone to an element of subjectivity in the review process

such as different decisions regarding ratings and synthesis might be made by other reviewers. In terms of age group, the inclusion criteria were children in middle childhood who are high functioning. EF, SP and anxiety measurement issues in another age and ability groups have not been considered. Furthermore, children with ASD are reported to be vulnerable to high anxiety across ages (van Steensel, et al., 2011) and abilities (Hallet et al., 2013; van Steensel et al., 2011).

3.16.4 Recommendations and Implications for Research

With regard to future directions, this review has highlighted that future studies should attempt to recruit a population based sample. If clinical samples are being recruited, it should be controlled with non-clinical, community ASD group to examine the uniqueness of the symptoms to treatment seeking youth with ASD. Most of the studies being reviewed utilized a small sample size. Future studies should attempt to recruit adequate samples guided by apriori power calculations (Cohen, 1998). Attempts should be made also to counter potential methodological threats by using a variety of measures of EF, SP and anxiety (both self/parental report and via observational methods). Careful attempts should be made to reduce potential confounds during choice of measures as well as during testing procedure. Further research also required to determine construct and discriminant validity of questionnaires measures.

All data generated from statistical analysis should be reported adequately with sufficient descriptive data, main statistical analysis and supplementary data (e.g. effect size; observed power). In terms of study design, most of the study design are cross-sectional which means causal conclusion cannot be drawn. Therefore, alternative models such as longitudinal or experimental designs should be adopted in the future.

More research is needed on the underlying neurophysiology of those symptoms and on the relationships between them and the symptoms and comorbidities related to ASD. Further understanding of the neural basis of EF, SP and anxiety in children with ASD should also be explored in future studies connected to neuroimaging techniques.

Cross-culturally, the association between SOR and anxiety was not replicated in a sample of Japanese children with ASD (Tsuji et al, 2009). The children with hypersensitivities did not differ significantly on the anxiety measure compared to the group with no hypersensitivities. Further investigation in other cultures is helpful in order established whether this issue is universal across culture or other factors could be taken into consideration when addressing this relationship cross-culturally.

SP symptoms have been correlated with several other problematic symptoms and behaviours associated with ASD, including intellectual disability, migraine headache and GI complaints. Future research should target on assessing the adaptive functioning level and quality of life of children with ASD associated with these comorbidities. Investigation of how these phenomenology related to parental distress and endophenotype may shed light on how to help improve the quality of life of children with ASD.

3.17 Conclusions

A full review of the current literature suggests that there is some evidence to suggest a link between EF and anxiety and SP atypicalities and anxiety in children with ASD. In terms of relationship between EF and anxiety the field is in it's infancy with only four papers addressing the research question identified, currently the evidence for an association is equivocal but there is some nascent evidence (Hollock et al. 2013; Zandt et al, 2009) This review suggests that future research should focus on the identification of the associations between specific EF functions, e.g. cognitive flexibility (Greenaway and Howlin, 2010; Lawson et al., 2014) and anxiety. The literature investigating SP atypicalities and anxiety is more fully developed and most of the papers under review found evidence for a relationship between SP anxiety, especially on sensory over-responsivity and anxiety. Only one study shows no relationship between these two constructs (Tsuji et al, 2009). This body of work is challenged by a range to address some of these in the future to determine if the reported findings are consistent across groups, developmental trajectories and cross-culturally.

Chapter 4. Relationship between Anxiety, Executive Functions and Sensory Processing in ASD

4.1 Introduction

Anxiety Disorders have not yet been fully or consistently examined in populations with neurodevelopmental disorders, including Autism Spectrum Disorder (ASD).The cause of ASD is not known, however, it is likely multifactorial with many agents, genetic and environmental, possibly affecting the presentation of symptoms (O'Roak & States, 2008). Estimates of the prevalence of anxiety disorders in the ASD population vary from 11% to 84% (Lang et al., 2011). Anxiety symptoms can interfere significantly with the child's ability to participate in home, school, and community activities (Russell & Sofronoff, 2005). In terms of the prevalence of specific anxiety in ASD, a meta-analysis of 31 studies conducted by van Stenseel et al., (2011) found that the most common anxiety diagnoses are specific phobia (30%), Obsessive Compulsive Disorder (OCD; 17%) and generalized anxiety (15%).

4.1.1 Relationship between executive functioning and anxiety

Executive functioning refers to higher-order cognitive processes such as response initiation and selection, planning and strategy formation, cognitive flexibility, and inhibition of a prepotent response (e.g. Stuss & Knight, 2002). These processes are typically affected following alterations in prefrontal cortex functioning arising through acquired abnormalities such as tumors, infections and brain injury. However, impairments in executive functioning are also exhibited in neurodevelopmental disorders that are associated with frontostriatal dysfunction, including autism spectrum disorders. Executive functioning deficits have been established as part of the neuropsychological profile of ASD (e.g. Hill, 2004).

Studies in executive functioning in ASD have identified problems in verbal fluency (e.g. Ambery et al., 2006; Turner, 1999) and cognitive flexibility in children and in adults (e.g. Lopez et al., 2005). However, there are also studies which have not

replicated executive deficits in ASD. For example, several studies do not report verbal fluency deficits (e.g. Russell et al., 2003) although Lopez et al. (2005) did find a marked perseveration difficulty. Other studies have also not replicated the findings of cognitive flexibility impairments (e.g. Russell, 2002). A small number of studies have compared executive functioning profiles between children with ASD and those with an anxiety disorder. For example, Zandt et al. (2009) studied neurocognitive patterns of functioning, with executive functioning (EF) impairments being hypothesized in both ASD and Obsessive Compulsive Disorders. Performance on neuropsychological tests assessing executive functioning showed a trend for children with ASD to perform poorly on tasks requiring generation of multiple responses, while children with OCD tended to demonstrate impairments on a task requiring inhibition. Parental ratings on a questionnaire measure of EF indicated impairments in both groups relative to typically developing controls.

Research focusing on neuropsychological features of anxiety disorders points towards possible deficits in organizational strategies in general, suggesting problems in executive functioning.

The most recent studies about neuropsychological correlates of anxiety in autism were initiated by Hollock et al. (2014). They examined relationships between multiple measures of executive functioning and social cognition on the severity of anxiety or depressive symptoms. Results indicated a significant association between poorer executive functioning and higher levels of anxiety, but not depression. This study was the first to report significant associations between executive functions and anxiety in ASD so far. Findings of this study suggest that poor executive functioning may be one factor associated with the high prevalence of anxiety disorder in children and adolescent with ASD.

4.1.2 Sensory processing in ASD

Additional features of ASD which may contribute to the onset and maintenance of anxiety are sensory processing abnormalities. Sensory processing (SP) difficulties have been reported in as many as 95% of children with autism (Baker et al., 2008, Baranek & Berkson, 1994, Baranek et al., 2006; Tomchek & Dunn,

2007). Dunn (1997) identifies that individual who under respond to sensory stimuli, demonstrating hyposensitivity, have a high neurological threshold requiring more intense amounts of input in order to register and elicit a response. In some of the literature, this is called sensory dormancy (Lai, Parham, & Johnson-Ecker, 1999). In contrast, children who over-respond have a low neurological threshold, resulting in strong reactions to sensory stimuli with very minimal input. This phenomenon is termed sensory defensiveness due to the behavioural responses associated with hypersensitivity or over responsiveness.

Children with ASD often exhibit sensory over-responsivity (SOR), an often clinically impairing condition characterized by heightened and unusual reactivity to sensations (Ben-Sasson et al., 2010, Baranek et al., 2006) Critical to the current PhD research, SOR has been reported to predict the development of anxiety in children with ASD (e.g. Ben-Sasson et al., 2009).

4.1.3 The impact of Sensory atypicalities

The interest in SP has grown in recent years (Lane et al., 2010). A meta-analysis of the sensory modulation literature in autism found support for the universality of these symptoms across the diagnostic spectrum (Ben-Sasson et al., 2009). Few studies have sought to investigate the relationship between SP difficulties and the clinical manifestations of ASD. Miller et al. (2005) found that children with high functioning autism or Asperger syndrome with lower arousal and who habituate to repeated sensory stimuli, tend to have greater communication and social impairment as well as increased repetitive behaviours. Kern et al. (2007b) concluded that multi-sensory disturbance was positively associated with autism severity in children but weakened in adolescents and adults.

Affective disorders such as depression and anxiety have been theorized to have a relationship with hyposensitivity and hypersensitivity to environmental sensory stimuli (Neal, Edelmann, & Glachan, 2002). There is evidence for relationships between the presence of anxiety and sensory hypersensitivity in ASD (Wigham et al. 2014, Lidstone et al., 2014, Mazurek et al., 2013, Green & Ben-Sasson, 2010, Ben-Sasson et al., 2008 & Pfeiffer et al., 2005).

However, the reason for the co-occurrence of SOR and anxiety is unknown, and there is little research on the development of SOR and anxiety symptoms in children with ASD. Green and Sasson (2010) reported that causal mechanisms may exist between SOR and anxiety. They propose three possible theories to explain the association between anxiety and SOR: (a) SOR is caused by anxiety; (b) Anxiety is caused by SOR; or (c) SOR and anxiety are causally unrelated but are associated through a common risk factor or diagnostic overlap. They examine support for each theory in the existing anxiety, autism, and neuroscience literatures. They proposed two models which are Primary Anxiety Models and Primary SOR model. In the Primary Anxiety model, anxiety contributes to SOR as generalized hyperarousal and hypervigilance focuses attention on a specific type of sensory stimulus. In the Primary SOR model, SOR contributes to anxiety as a specific over-reaction generalizes to an environment or situation through context conditioning. In their study, they also addressed the possibility that a common risk factor such as amygdala abnormalities may contribute independently to each condition through overestimation of the threat value of a sensory stimulus which triggers an enhanced response to that stimulus.

In another study, Green et al. (2011) focused on the emergence of and bidirectional effects between anxiety and SOR in toddlers with ASD. SOR positively predicted changes in anxiety over and above child age, autism symptom severity, non-verbal developmental functioning, and maternal anxiety, but anxiety did not predict changes in SOR. Results suggest that SOR emerges earlier than anxiety, and predicts later development of anxiety.

Pfeiffer et al. (2005) attempted to determine whether there were any significant relationships between dysfunction in sensory modulation, symptoms of affective disorders, and adaptive behaviours in children and adolescents with Asperger's disorder between 6 and 17 years of age. The results indicated that there were significant strong positive correlations between sensory defensiveness and anxiety.

4.1.4 Links between EF and SP in ASD

Autism is a developmental disorder not simply in terms of taxonomy but in terms of its detailed aetiology. Variation in phenotypes and severity within ASD is very broad which further suggests the involvement of multiple predisposing factors interacting in complex ways with normal developmental course (Belmonte et al., 2004). Therefore, ASD must be approached as an emergent property of developmental interactions between many brain regions and functions (Johnson et al., 2002).

4.1.5 Limitations of current findings

Results of investigations into neuropsychological functioning have been inconsistent so far. Several studies with participants with OCD suggest impairment on tests of set shifting, fluency, planning and problem solving and visuospatial memory (e.g. Behar et al. 1994; Beers et al. 1999). The majority of studies suggest that OCD is commonly associated with mild cognitive dysfunction on tasks involving executive functioning and nonverbal memory (e.g, Greisberg & McKay, 2003; Kuelz, Hohagen & Voderholzer, 2004a).

Given that ASD is associated with the presence of both EF deficits and anxiety, a next logical step is to explore whether there are important relationships between these two features of the disorder and whether EF deficits are associated with a specific anxiety profiles in ASD.

4.1.6 Aims of study

In this study, we are interested in determining the relationships between executive functions and sensory processing in relation to anxiety in children with ASD.

4.1.7 Hypotheses

Autistic children with greater degree of executive and sensory processing dysfunctions will have higher anxiety scores.

a. Specific Hypothesis

The specific hypotheses are as follow:

1. There will be a significant negative correlation between total anxiety score on the SCAS and total score on the NEPSY-II
2. There will be a significant negative correlation between total anxiety score in the SCAS and total score on the SSP[1]
3. There will be is a significant negative correlation between scores on the OCD sub-scale of the SCAS and the total score of NEPSY-II
4. There would be a significant negative correlation between the Social Phobia subscale of the SCAS and total score on the SSP.
5. There will be a significant negative correlation between total scores of the CL subtest (planning and organization) and total score of SCAS.
6. There would be a significant negative correlation between total score of the animal sorting test (initiation, cognitive flexibility and self-monitoring) in NEPSY-II and total score on the SSP.
7. Executive dysfunction and sensory processing difficulties will predict parent rated anxiety.
8. Executive dysfunction and sensory processing difficulties will predict parent rated separation anxiety
9. Executive dysfunction and sensory processing difficulties will predict parent rated panic and agoraphobia.
10. Executive dysfunction and sensory processing difficulties will predict parent rated Generalized Anxiety Disorder (GAD).

[1] Low scores on SSP indicate more atypicality.

4.2 Methods

4.2.1 Design

The study used a single group cross-sectional research design.

4.2.2 Participants

a. Power of Calculation

Statistical power analysis exploits the relationships among the four variables involved in statistical inference: sample size (N), significance criteria (α), population effect size (ES) and statistical power. Correlational analysis will be used as statistical analysis for this study. The level of alpha will be set at .05 to control for type 1 error. Given the clinical nature of this study, a large effect size is predicted. According to Cohen (1992), a sample size of 38 is required to obtain an acceptable level of power (.80). In this study our sample size (N) is 36 which slightly at the lower acceptable level. However, it is comparable with other studies that have adopted the same research framework [e. g. Little et al. (2013): N=25; Reid (2013): N=35 & Crooks (2013): N=38].

b. Sample Descriptions

Recruitment took place via local special and mainstream school settings or charity/support groups. No control group was recruited. However, in this research the participants was controlled in terms of their age, ability and autism severity. Furthermore, the aims of the study are to examine relationships between variables rather than differences between those with ASD and typically developing controls. In addition, this study is comparable with other autism study of the same design (e.g. Rodgers et al. (2012 a & b).

Parents and young people were provided with information sheets and consent/assent forms.

c. Inclusion and Exclusion Criteria

All child participants had been diagnosed with autism or Asperger Syndrome based on DSM-IV by clinical professionals. Participants were included if they were aged between 8 - 16 years with a full scale IQ (FSIQ) over 64 as measured by WASI-II, with no identified comorbidity with other neurodevelopmental conditions and physical disabilities. The exclusion of comorbidity was stated in the information sheet for parents as well as in the flyers sent to local special and mainstream school settings or charity/support groups. Parents were required to be fluent in English language to meet the language demands of the measures used.

4.2.3 Procedure

a. Ethical Issues and Consent

Ethical approval and indemnity was provided Newcastle University ethics committee (See **Appendix E**). Participants were required to provide consent for participation prior to any data collection and opportunity was given to ask questions about the research. The procedure for providing consent started with an invitation letter that was sent to the identified families. Together with the covering letter, the information sheets and consent forms were also included (See **Appendix G**), and a stamped addressed envelope. Families were asked to return the expression of interest form to the research team who then contacted them directly to arrange an appointment for data collection.

b. Testing Procedure

Data collection took place at the family's home or at school. The children were required to complete a battery of tasks which included the Developmental NEuroloPSYcological Assessment –Version II (NEPSY-II) and the Wechsler Abbreviated Scale of Intelligence – Second Edition (WASI-II) and questionnaires measures.

If the testing session took place at family's home, the session was started with brief conversation with parents about diagnosis, intervention, medications and

school attended. Following that, the Principal Investigator reiterated the purpose of visit and also explained the tasks. Parents were then asked to complete the parent rated The Spence Children's Anxiety Scale (SCAS), The Social Responsiveness Scale (SRS), Short Sensory Profile (SSP) and parent rated Children's Obsessional-Compulsive Inventory-Revised (CHOCHI-R) while the Principal Investigator was engaged with the child. The children completed the child rated SCAS first, followed by WASI-II and NEPSY-II. A short break was given in between the tasks on the test batteries if the child required it. It took approximately 90 minutes to complete all the test batteries and questionnaires measures.

If the testing session took place at school, the principal investigator liaised with autism resource teacher. The principal investigator was introduced and reiterated the purpose of the session and what it will involve. The testing began with administration of SCAS, followed by the test batteries (The WASI-II and NEPSY-II). A short break was also given in between the tasks on the test batteries if required. Questionnaires for parent participants (The parent and child rated SCAS, SRS and SSP) were sent to parents through the autism resource teacher. The parent returned them to school and Principal Investigator collected from school.

As a token of appreciation, children were given a stationary pack and a certificate of appreciation worth approximately £3 after the testing session completed.

4.2.4 Measures

The children had already received an ASD diagnosis from a local clinician therefore diagnosis was not re-assessed as part of the current study. However, parents were asked to complete the Social Responsiveness Scale (SRS; Constantino and Gruber, 2005). The Wechsler Abbreviated Scale of Intelligence (WASI: Wechsler, 1999) was used to provide an estimate of ability level.

a. The Social Responsiveness Scale (SRS; Constantino and Gruber, 2002)

SRS is the 65 item rating scale which provides a measure of social impairment (mild to severe), resulting in a total score and five subscale scores. The SRS inquires about a subject's ability to engage in emotionally appropriate reciprocal social interaction, which is believed to be the core domain of deficiency in all ASD domains. It has been extensively tested in both clinical and population-based samples (Constantino et al, 2005), and can be completed by parents, teachers or other frequent carers in 15–20 min. Each item is rated on a scale from 0 (not true) to 3 (almost always true).

Scores on the SRS are highly heritable (Constantino et al 2003b), generally unrelated to IQ (Constantino et al 2003a), and continuously distributed in the general population (Constantino and Todd 2003); they distinguish patients with autism spectrum disorders from those with other child psychiatric conditions (Constantino et al 2000; Constantino and Todd 2003).

The SRS inquires about a subject's ability to engage in emotionally appropriate reciprocal social interaction, which is believed to be the core domain of deficiency in all autism spectrum disorders. Reciprocal social behaviour (RSB) requires an individual to be cognizant of the emotional cues of others, to interpret those cues appropriately, to respond appropriately to what he or she interprets, and to be motivated to engage in social interactions with others.

In terms of utility of the SRS over other extensive screening tools, such as the Autism Diagnostic Interview-Revised (ADI-R), research findings consistently show that brief scales like the SRS have strong psychometric support and compare favourably with the ADI-R and offer a valid, brief and cost effective alternative to lengthy and expensive measure (Murray et al., 2011). SRS normative data was obtained from 2500 US children and adolescents, aged 4-18 years (e.g. Constantino et al 2000, 2003a; Constantino and Todd 2000, 2003). It has conclusively been shown that the SRS performs in similar ways in UK and USA general population samples of children and can be used without modification in the UK (Wigham et al., 2012).

In one of the recent studies exploring the sensory responsiveness and social severity among ASD using SRS, it was found that significant relationships were found between social responsiveness scale scores and each of the six sensory profile sensory system scores for children with High Functioning ASD and controls (Hilton et al., 2010). This has further proven the utilities of SRS as a measure of ASD symptoms and social impairment.

In this study, the child and adolescent version was used and completed by parents.

b. Weschler Abbreviated Scale of Intelligence – Second Edition (WASI-II), (Weschler, D. 1999)

The WASI-II is an abbreviated assessment of intelligence that covers both verbal and nonverbal domains with four subtests including vocabulary, block design, similarities, and matrix reasoning ~~(appendix)~~. The WASI-II is a widely used measure in both clinical and non-clinical samples when there is no need to provide a full cognitive profile. Normative data was based on approximately 2,300 individuals aged 6–90 on a national sample representative of the US (Weschler, 1999). It is a reliable, brief measure of intellectual ability in clinical, educational and research settings for ages 6 to 89 years.

The WASI is a widely used measure in both clinical and non-clinical samples when there is no need to provide a full cognitive profile In addition, the WASI correlates highly (verbal IQ score = 0.88, performance IQ = 0.84, full-scale IQ score = 0.92) with the Wechsler Adult Intelligence Scale (WAIS-III: Wechsler, 1999b). It estimates VIQ, PIQ, and FSIQ. An average IQ on the psychometric curve is demarcated at a FSIQ of 100. Standard deviations are significant at 11 (p.05) and 15 points (p.01) and denote above average intelligence at 115–129 and superior intelligence at 130 or above for full scale IQ. The WASI-II was chosen in this study due to the speed of administration. It takes approximately 20-30 minutes to complete the WASI-II and was individually administered to participants.

4.2.5 Experimental Measures

a. The Spence Children's Anxiety Scale-SCAS (Spence, 1998)

The Spence Children's Anxiety Scale (Spence, 1998) is a self-report measure of anxiety originally developed to examine anxiety symptoms in children aged 8–16 years. It also includes a parallel parent report measure. The SCAS consists of 44 items, 38 of which assess specific anxiety symptoms relating to six sub-scales, namely social phobia, separation anxiety, panic attack/agoraphobia, obsessive-compulsive disorder, generalized anxiety and physical injury fears. The remaining six items serve as positive "filler items" in an effort to reduce negative response bias.

Respondents are asked to indicate frequency with which each symptom occurs on a four-point scale ranging from Never (scored 0) to Always (scored 3). A total SCAS score is obtained by summing scores of the 38 anxiety symptom items.

Previous studies have demonstrated high internal consistency, high concurrent validity with other measures of child and adolescent anxiety, and adequate test–retest reliability (Wigham & McConacchie, 2014). Both parent and child version will be administered to assess anxiety symptoms. It has been used extensively in ASD (Chalfant et al., 2006; Russell and Sofronoff, 2005, Rodgers et al., 2012).

b. Developmental NEuroloPSYcological Assessment –Version II (NEPSY-II; Korkman et al. 2007)

In order to measure executive functioning, Developmental NEuroloPSYcological Assessment –Version II (Korkman et al. 2007) NEPSY-II was used. The NEPSY-AI (Korkman et al. 2007a) is a comprehensive, co-normed, and multi domain neuropsychological battery designed for assessing neurocognitive abilities in pre-schoolers, children, and adolescents. It is a flexible battery of subtests that designed to allow the administration of specific subtests, group of subtests, or the entire battery. The NEPSY-II normative sample is national, stratified random sample consisting of 1,200 preschoolers, children and adolescents between ages of 3 and 16 years. For the purpose of this research, the Executive

Function/Attention subtests were administered. It takes around 30-45 minutes to administer.

The NEPSY-II provides four different types of scores. Primary scores are presented as age-adjusted scaled scores (mean = 10, standard deviation = 3) and represent the central clinical aspect of the subtest. The second type of score is the process score. Process scores assess more specific abilities, skills, or error rates from a subtest and can be presented as scaled scores, percentile ranks, or cumulative percentages. The third type of score is a contrast score. Contrast scores are presented as scaled scores and allow for a statistical comparison between high and low abilities. The fourth type of score is behavioural observations, which quantify behaviours occurring during the assessment.

Overall, internal reliability evidence for the NEPSY-II is impressive which shows that across the age groups, the internal reliability coefficients are for the most part adequate to very high. Test-retest reliability correlations for many NEPSY-II subtests are generally adequate to high.

For the purpose of this research, the Executive Function/Attention subtests were administered. It takes around 30- 45 minutes to administer. The EF domains comprises of seven subtests:

a. Animal Sorting (AS): This subtest is designed to assess the ability to formulate basic concepts, to transfer those concepts into action, and to shift set from one concept to another. The child sorts cards into two groups of four cards each, using various self-initiated sorting criteria.

b. Auditory Attention (AA) and Response Set (RS): This subtest has two parts. Auditory Attention is designed to assess selective auditory attention and the ability to sustain it (vigilance). Response Set is designed to assess the ability to shift and maintain a new and complex set involving both inhibition of previously learned responses and correctly responding to matching or contrasting stimuli. The child listens to a series of words and touches the appropriate circle when he or she hears a target word.

c. Clocks (CL): This subtest is designed to assess planning and organization, visuoperceptual and visuospatial skills, and the concept of

time in relation to analog clocks. For each drawing item, the child draws the image of a clock and places the hands where the examiner indicates. For visual items, the child reads the time on clocks that either have or do not have numbers.

d. Design Fluency (DF): This subtest is designed to assess the behavioural productivity in the child's ability to generate unique designs by connecting up to five dots, presented in two arrays: structured and random. The child draws as many designs as he or she can on each array within a specified time limit.

e. Inhibition (IN): This timed subtest is designed to assess the ability to inhibit automatic responses in favour of novel responses and the ability to switch between response types. The child looks at a series of black and white shapes or arrows and names either the shape or direction or an alternate response, depending on the colour of the shape or arrow.

Scores on the NEPSY-II are divided into four categories: Primary, process, contrast and behavioural observations. The primary score has a special type of score, which is known also as combined score. The combined score is generated to emphasize the construct being measured and made by combining two measures within the subtests. For example, combined score for Inhibition Switching (INS) is created from combining normed scores for the completion time and errors. The total combined score was obtained by adding all the combined score for each subtests and averaging the total combined scores. Low total combined scores on EF subtests are indicative of poor EF abilities and high combined scores are indicative of performance at expected level of EF. Score at borderline level indicates that their EF function are not as developed as 75% of their peers.

c. The Short Sensory Profile (Dunn, 1999)

In order to measure sensory processing, the Short Sensory Profile (Dunn, 1999) inventory was used. It is a caregiver questionnaire which measures children's responses to sensory events in everyday life. It contains 38 items. Caregivers

complete the questionnaire by reporting how frequently their children respond in the way described by each item; they use a 5 point likert scale (nearly never, seldom, occasionally, frequently, and almost always).

The SSP includes seven sections: tactile sensitivity, taste/smell sensitivity, movement sensitivity, under responsive/ seeks sensation, auditory filtering, low energy/weak, and visual/auditory sensitivity. Internal reliability of the "total" and "section" scales ranges between .70 and .90. Inter-correlations of the SSP total and section scores range between .25 and .76.

4.2.6 Statistical analysis

Statistical Package for Social Sciences, version 21 (SPSS 21) was used for all statistical analyses. Several statistical analyses were used to examine the hypotheses. Multiple regression analysis was used to examine the main hypothesis. The relationship between each variable and the potential differences between subgroups were being examined by Pearson Product Moment Correlations.

4.2.7 Final Sample Size and data set

36 families consented to participate in this study. Summary of final sample size and data set entered into analyses is as follows:

- **SCAS-P**

2 parents did not return the questionnaire which resulted in missing data for the whole SCAS-P. Therefore, the analyses on parent rated SCAS was based on sample size of 34.

- **SCAS-C**

There are no missing values or incomplete data for this questionnaire. Therefore final data set entered into analyses for child rated SCAS was based on sample size of 36.

- **NEPSY**

Two children did not complete the NEPSY. One participant managed to complete all the subtests except the Inhibition-switching (INS) subtest. The total score for this participant was based on the mean of total scores for 7 subtests and the data for the rest of subtests was still used for this participant. Therefore, the analyses used in the NEPSY was based on sample size of 34.

- **SSP**

There are 4 parents who did not complete and return the SSP which resulted in missing data for the whole questionnaires for 4 participants. Therefore, the analyses used in the SSP was based on sample size of 32.

- **SRS**

There are 4 participants who have complete missing items for the whole questionnaires. Therefore, the analyses used in the SRS was based on sample size of 32.

4.3 Results

4.3.1 Data Screening

a. Missing data

During analyses, management of missing data was handled via listwise and pairwise deletion (SPSS default) based on analysis. List wise deletion was used to deal with the missing data for all the regression analyses and pairwise deletion was used for correlational analyses. As a result, sample sizes differed slightly from one analysis to the next. Therefore, in the result section, the sample size that was entered into the analyses will be reported in each of the individual analyses undertaken in this study.

b. Outliers

Visual inspections of stem and leaf detected no outliers in the parental report measures of ASD characteristics (SRS), general ability (WASI-II), anxiety (parent and child rated SCAS), executive dysfunctions (NEPSY-II) and sensory processing (SSP).

c. Normality

The distribution of scores on each measures were examined using Kolmogorov-Smirnov calculations in order to examine whether the data met the assumptions of normality required for parametric testing. All variables used in this analysis met the assumptions.

4.3.2 Internal consistency of questionnaire measures

According to Field (2005), a Cronbachs alpha of at least 0.7 indicates good reliability. Reliability tests (Cronbach's alpha) were carried out on all of the questionnaires measures. (See table 4.1).

Table 4.1

Participants' descriptive statistics on all measures

	Mean	SD	Range	**Cronbach's alpha**
NEPSY-II total score (N=34)	9.79	4.24	1-15	
SCAS scores				
Parent Rated SCAS total score (N=34)	33.00	17.28	1-68	**.737**
Child Rated SCAS total score (N=36)	35.86	18.68	0-77	**.760**
SRS total score (N=32)	107.97	30.85	41- 168	**.857**
SSP total score (N=32)	119.81	28.49	64 - 179	**.908**

Key: NEPSY-II– Developmental NEuroloPSYcological Assessment –Version II; SCAS-C - The Spence Children's Anxiety Scale – Child version; SCAS-P - The Spence Children's Anxiety Scale – Parent version; SRS – Social Responsiveness Scale; SSP – Short Sensory Profile

All questionnaires measures achieved a Cronbach's alpha >.7 which demonstrated good internal consistency. The SSP total score demonstrated excellent internal consistency (Cronbach's alpha .908). Therefore, all of the questionnaires measures used in this study can be reported to have good levels of reliability (Field, 2005).

4.3.3 Demographic Data

a. Inclusion of Participants Based on Diagnosis, IQ and SRS Score

All participants in this study have a diagnosis of autism or Asperger Syndrome based on DSM-IV provided by a clinical professional. Participants were included if their WASI-II estimated full scale IQ was 65 or higher.

The Social Responsiveness Scale (SRS) was used to confirm the diagnosis. . The suggested cut off score for the SRS is total T-score of 60. It has a range score of 60 through 75 which is the mild to moderate range, 76 or higher which is the severe range. Scores in this range are strongly associated with clinical diagnosis of Autistic disorder, Asperger's Disorder, or more severe cases of PDD-NOS (Constantino et al, 2005). T-score of 56 or less is in the normal range. However, this cut-off can be adapted for individual studies and lower cut-off may be appropriate for children with high-functioning autism or Asperger Syndrome. One of the participants has a T-score of 56 which is in the lowest range was also included.

b. Characteristics of Participants

Out of 36 participants, 31 were male and 5 female. Table 4.2 gives the chronological age and the WASI-FSIQ of participants. The mean age was 11 years and 4 months, mean IQ was 84.67. Table 4.2 shows Participant's demographic data.

Table 4.2

Participant's demographic data

N=36	Mean	SD	Range
Age (year and months)	11.04	2.89	7.05 - 17.09
WASI-II (FSIQ)	84.67	13.49	64.00 - 116.00

In this study, The Social Responsiveness scale was also used to measure autistic social impairment. Table 4.3 shows the profile of SRS scores across 5 factors.

Table 4.3

Profile scores across 5 factors on the Social Responsiveness Scale (SRS)

SRS Factors (N=32)	Mean (SD)	Range	T-Score	Classification
Social Awareness	13.03 (4.11)	2-20	72	Mild to moderate
Social Cognition	21.27(5.72)	7-34	83	Severe
Social Communication	36.34(9.35)	14-57	81	Severe
Social Motivation	18.55(7.01)	5-29	80	Severe
Autistic Mannerisms	23.14(7.29)	8-35	90	Severe
Total Raw score	112.62(27.46)	41-168	87	Severe

The total mean score of 112.62 (sd 27.46) classified as severe interference in every social interactions. Social Cognition, communication, motivation and autistic mannerisms subscale are in the severe range as well. The social awareness subscale falls within the mild to moderate range.

4.3.4 Descriptive Statistics

a. Anxiety-Spence Childhood Anxiety Scale (SCAS)

Anxiety in this study was assessed by the Spence Childhood Anxiety Scale (SCAS) completed by the parent and the children. SCAS assesses the severity of anxiety symptoms broadly in line with the dimensions of anxiety disorders proposed by the DSM-V. A higher indicates score more elevated anxiety symptoms. Table 4.4 shows the profile scores for the children's version across 6 anxiety subscales.

Table 4.4

Spence Childhood Anxiety Scale (SCAS)-Children version

SCAS-Children Subscale, N=36	Mean	SD	Range	Gillot et al. (2001) mean (sd), N=15
Separation Anxiety	5.61	3.59	0-13	7.07(4.17)
Social Phobia	6.14	4.22	0-16	5.13(3.66)
Obsessive Compulsive	7.11	4.48	0-17	8.47(3.68)
Panic/agoraphobia	6.36	4.83	0-18	5.33(4.25)
Physical Injury Fears	4.28	3.35	0-12	4.93(3.31)
Generalized anxiety	6.33	3.85	0-15	5.67(2.87)
Total	35.86	18.68	0-77	Not available

In this study the parent has helped to rate the anxiety symptoms as well. Table 4.5 shows the parent score on SCAS.

Table 4.5

Spence Childhood Anxiety Scale (SCAS)-Parent version

SCAS-Children Factor, N=34	Mean	SD	Range	Rodgers et al. (2012) mean (sd), N=68
Separation Anxiety	6.61	18.68	0-77	9.94(3.3)
Social Phobia	6.91	4.96	0-18	10.88(3.2)
Obsessive Compulsive	4.41	3.28	0-11	8.58(3.8)
Panic/agoraphobia	4.41	3.65	0-17	8.55(4.6)
Physical Injury Fears	4.88	3.13	0-11	6.91(3.0)
Generalized anxiety	5.71	3.38	0-12	9.45(2.8)
Total	33.00	17.28	1-68	54.3 (14.8)

Intra-class correlations were used to assess agreement between total scores of parent and child rated SCAS (N=34 dyads). The Parent and child agreement was low and not significant (r=.243, p=.081).

b. Executive functioning subtests of Developmental NeuroPsychological Assessment-Version II (NEPSY-II)

The subtests included in the NEPSY-II Attention and Executive Functioning domain are Animal Sorting, Auditory Attention and Response Set, Clocks, Design Fluency, Inhibition and Statue. In this study all the subtests was administered except the statue as it is designed to assess children from age 3 to 6 years old.

The subcomponents of attention and executive functioning that are assessed include inhibition of learned and automatic responses; monitoring

and self-regulation, vigilance; selective and sustained attention; the capacity to establish, maintain, and change a response set; nonverbal problem solving, planning and organizing a complex response; and figural fluency.

Table 4.6

Executive functioning profile scores on the Developmental NEuroPSYchological Assessment version II (NEPSY-II)

NEPSY-II Factors	Mean	SD	Range
Animal Sorting (Initiation, cognitive flexibility) N=35	5.34	1.75	2-10
Auditory Attention (selective and sustained attention, inhibition) N=34	3.66	0.99	2-5
Response Set(selective and sustained attention, inhibition and working memory) N=34	9.47	3.77	1-14
Design Fluency (initiation and productivity, cognitive flexibility) N=34	7.52	3.74	1-16
Clock (planning and organization) N=34	9.21	5.81	1-19
Inhibition-Inhibition(inhibitory control) N=34	10.06	0.21	1-15
Inhibition-Switching(inhibitory control and cognitive flexibility) N=35	9.79	4.24	1-15

c. Sensory Processing - Short Sensory Profile (SSP)

The short sensory profile elicits parental reports of sensory symptoms in children. The norm-reference classification system describes the children sensory processing abilities for each factor as Typical performance, Probable Difference, or Definite Difference. A lower score on the SSP indicates a greater degree of impairment.

Table 4.7

Short Sensory Profile Subtests Scores

SSP Subtests N=32	Mean (SD)	Range	Classification (by mean score)
Tactile sensitivity	25.28(6.14)	9-35	Definite difference
Taste/Smell Sensitivity	11.19(5.72)	4-20	Definite difference
Movement Sensitivity	10.78(3.60)	5-15	Definite difference
Underresponsive/Seeks Sensation	19.97(8.25)	8-35	Definite difference
Auditory Filtering	14.69(4.50)	6-25	Definite difference
Low Energy/Weak	21.16(8.70)	6-30	Definite difference
Visual/Auditory Sensitivity	16.84(5.38)	6-25	Probable Difference
Total	119.81(28.49)	64-179	Definite difference

From the above table, the mean total scores is 119.81 which indicates impaired SP. In SSP, scores 38 through 141 fall within definite difference category.

4.3.5 Correlational Analysis

a. The relationship between Executive Dysfunctions and Anxiety in ASD

It was predicted that there would be a significant negative correlation between total anxiety score on the SCAS and total score on the NEPSY-II. Correlational analysis was undertaken on both the parent and child rated anxiety scores and the NEPSY-II total score. The result of this analysis can be found in table 4.8.

Table 4.8.

Correlations between NEPSY-II and parent and child rated SCAS

Variable 1	Variable 2	r	p value
Parent rated SCAS (total) N=34	NEPSY-II (total) N=34	-.031	.865
Child rated SCAS (total) N=36		.102	.567

Significant correlations were found between EF ability and anxiety as rated by both the parent and child rated anxiety. Therefore, the prediction was unsupported.

b. Relationship between Sensory Processing and Anxiety in ASD

It was predicted also that there would be a significant negative correlation between total anxiety score in the SCAS and the total score on the SSP. A low score on the SSP indicates more impairment. In terms of anxiety score, the analysis was performed on both the parent and child rated SCAS. Result of the correlational analysis is as per table 4.9.

Table 4.9.

Correlations between SSP and parent and child rated SCAS

Variable 1	Variable 2	r	p value
Parent rated SCAS (total) N=34	SSP (total) N=32	-.459**	.008
Child rated SCAS (total) N=36		-.031	.867

**Correlation is significant at the 0.01 level (2 tailed)

A significant correlation was found between scores on the SSP and parent rated anxiety score (r = -.459, p = .008). No significant correlation found between scores on the child rated SCAS and the SSP. Therefore, the prediction is partially supported.

c. Relationship between specific anxiety subtypes and EF

In this analysis, the relationship between specific anxiety subtypes and EF was explored. It is predicted that there would be a significant negative correlation between the OCD subscale of the SCAS and total score on the NEPSY. No specific predictions were made regarding the other anxiety subscales and exploratory analyses were undertaken on the remaining subscales. The total NEPSY score was correlated with the subscale scores of both the parent and child rated SCAS. Table 4.10 shows result of this correlational analysis.

Table 4.10

Correlations between anxiety subtypes on parent rated SCAS and EF

Variable 1 N=34 (each subscale)	Variable 2	r	p value
Separation Anxiety (total)	NEPSY-II (total),	.096	.601
Social Phobia (total)	N=34	.093	.613
Obsessive Compulsive (total)		-.015	.933
Panic/Agoraphobia (total)		-.390*	.027
Physical Injury (total)		-.011	.952
Generalized Anxiety (total)		.044	.811

*. Correlation is significant at the 0.05 level (2 tailed)

The above results indicates that Panic/Agoraphobia subscale was negatively correlated with EF (r = -.390, p = .027). We found no relationship between OCD and EF.

In the next analysis, the anxiety subscales on the child rated SCAS were correlated with the NEPSY total score. The result of this correlational analysis is shown at table 4.11.

Table 4.11.

Correlations between anxiety subtypes on child rated SCAS and EF

Variable 1 N=36 (each subscale)	Variable 2	r	p value
Separation Anxiety (total)	NEPSY-II (total), N=34	.081	.648
Social Phobia (total)		.061	.732
Obsessive Compulsive (total)		.170	.336
Panic/Agoraphobia (total)		-.090	.614
Physical Injury (total)		.251	.152
Generalized Anxiety (total)		.085	.635

The above correlational analysis result shows no significant correlations were found between any of the anxiety subtypes as rated by the children and EF. Therefore, the prediction that there will be a significant negative correlation between the OCD subscale of the SCAS and total score on the NEPSY was unsupported.

d. Relationship between specific anxiety subtypes and SP

In this analysis, the relationship between specific anxiety subtypes and sensory processing will be investigated. Previous studies shows that SP dysfunctions were correlated with greater social impairment (Miller et al., 2005) and poor social performance (Baker et al., 2008). Therefore, it was predicted that there will be a significant negative correlation between scores on Social Phobia subscale of the SCAS and total score of the SSP. No specific predictions were made regarding the other anxiety subscales.

The total score of each of the anxiety subscales on the parent rated SCAS were correlated with the total score of SSP. The following table shows results of this correlational analysis.

Table 4.12

Correlations between anxiety subtypes on parent rated SCAS and SP

Variable 1 N=34 (each subscale)	Variable 2	r	p value
Separation Anxiety (total)	SSP (total)	-.524**	.002
Social Phobia (total)	N=32	-.234	.197
Obsessive Compulsive (total)		-.166	.364
Panic/Agoraphobia (total)		-.386*	.029
Physical Injury (total)		-.310	.085
Generalized Anxiety (total)		-.531**	.002

**. Correlation is significant at the 0.01 level (2 tailed)

*. Correlation is significant at the 0.05 level (2 tailed)

The above findings indicate that Separation anxiety, Panic/Agoraphobia and Generalized anxiety were correlated with SP dysfunctions [(r=-.524, p=.002); (r- .386, p=.029); (-.531, p=.002)]. Therefore, the prediction that that there will be a significant negative correlation between scores on Social Phobia subscale of the SCAS and total score of the SSP was not supported based on the SCAS subscale scores rated by parents, however significant relationships were found for other anxiety sub-types.

In the next analysis, the parent rated subscale scores on the SCAS was replaced by the child rated subscale scores. They were correlated with total score of the SSP. Table 4.13 below, represents result of this correlational analysis.

Table 4.13.

Correlations between anxiety subtypes on parent rated SP

Variable 1 N=36 (each subscale)	Variable 2	r	p value
Separation Anxiety (total)	SSP (total)	-.208	.253
Social Phobia (total)	N=32	.033	.858
Obsessive Compulsive (total)		.066	.720
Panic/Agoraphobia (total)		.079	.667
Physical Injury (total)		.235	.195
Generalized Anxiety (total)		-.069	.709

The above correlational analysis result indicated that there is no significant relationships found between anxiety subtypes and SP dysfunctions. The prediction is therefore unsupported.

e. Relationship between specific EF subtest and anxiety

Previous literature has shown that children with ASD and OCD tended to demonstrate impairments on a task requiring inhibition (Zandt et al., 2009). Greisberg and McKay (2003) examined neuropsychological features of OCD and found deficits in organizational strategies in EF. Therefore, it is predicted that there will be a significant negative correlation between total score on the CL subtest (planning and organizations) and total score on the SCAS. No specific predictions were made regarding the other EF subscales.

In this section, the relationship between specific EF subtests on the NEPSY-II and anxiety scores were examined. Following the above model, the total score of EF subtests were correlated with the total score of both parent and child version of SCAS. The total score of parent rated SCAS was correlated first with the total scores of the NEPSY subtests. The following table (table 4.14) shows the results of this analysis.

Table 4.14

Correlations between NEPSY subtests and parent rated SCAS

Variable 1	Variable 2	r	p value
Animal Sorting (total, N=35)	Parent rated	.019	.909
Auditory Attention (total, N=34)	SCAS (total)	-.073	.696
Response Set (total, N=34)	N=34	-.038	.837
Clock (total, N34)		.126	.498
Design Fluency (total, N=34)		.064	.731
Inhibition-Naming (total, N=34)		.039	.835
Inhibition-Inhibition (total, N=34)		-.135	.469
Inhibition-Switching (total, N=33)		-.156	.402

The above findings indicate that there are no significant correlations between any of the EF subtests and the anxiety score as rated by the parents. Therefore, the prediction is unsupported.

In the next stage, correlational analysis on the relationship between specific EF subtests and total scores of child rated SCAS was also performed. Table 4.15 shows findings of this analysis.

Table 4.15

Correlations between NEPSY subtests and Child rated SCAS

Variable 1	Variable 2	r	p value
Animal Sorting (total, N=35)	Child rated	.199	.267
Auditory Attention (total, N=34)	SCAS	.098	.587
Response Set (total, N=34)	(total)	.137	.447
Clock (total, N=34)	N=36	.027	.881
Design Fluency (total, N=34)		.199	.268
Inhibition-Naming (total, N=34)		.235	.187
Inhibition-Inhibition (total, N=34)		.003	.989
Inhibition-Switching (total, N=33)		-.191	.287

From the above table, it was found that there are no significant correlations between specific EF subtests and anxiety as rated by the children. This finding is consistent with correlational analysis between EF subtests and parent rated SCAS. Therefore, the prediction is unsupported.

4.3.6 Multiple Regression Analysis

a. Predicting Anxiety (parent rated) from Sensory Processing and Executive Dysfunctions

Literature findings suggest that the presentation of anxiety may be affected by older age and degree of social impairment (White et al., 2009), but there are still gaps in the identification of risk factors and etiological pathways for anxiety in children with ASD that remain unexplained *(ibid*). Findings from our correlational analysis suggest that there is a significant relationship between parent rated anxiety and sensory processing. In terms of the relationships between EF and anxiety, our findings showed that no significant correlations between EF difficulties and anxiety as rated by both the parent and children. Further examination of the relationship between specific anxiety subtypes and EF indicates that the Panic/Agoraphobia subscale was significantly correlated with EF.

Therefore, multiple regression analysis was undertaken in order to examine whether scores on the NEPSY or SSP predicted heightened anxiety in children with ASD.

A three stage hierarchical multiple regression was conducted with the total score on parent rated SCAS entered into the analyses as a dependent variable. The first model consists of demographic variables. Age and autism severity (SRS total) were included in the first block. The SSP total score was then entered into the model (2^{nd} block), followed by EF total score in the third block.

Regression analyses were run in order to see which predictors contribute substantially to the model's ability to predict the outcome (anxiety).

Prior to interpreting the main outcome of the hierarchical multiple regression, the fitness of the regression model was assessed using the Model Summary and ANOVA tables from SPSS. Table 4.16 and 4.17 below shows the data from these analyses.

Table 4.16

Summary of fitness of regression model for predictors of heightened anxiety in ASD (N=29)

Model	Dependent variable	Independent variable	R	R^2	ΔR^2	Durbin-Watson	F	P value
Step 1		**(Constant)**	**.606**	**.367**	**.318**		**7.534**	**.003***
	Parent	**Age (years)**						
	rated	**SRS (total)**						
Step 2	**SCAS**	**(Constant)**	**.697**	**.485**	**.424**		**7.858**	**.001***
		Age (years)						
		SRS (total)						
		SSP (total)						
Step 3		**(Constant)**	**.706**	**.499**	**.415**	**1.907**	**5.965**	**.002***
		Age (years)						
		SRS (total)						
		SSP (total)						
		NEPSY						
		(total)						

***p < .05**

Table 4.17

Summary of Hierarchical Regression Analysis for Variables predicting anxiety in ASD (N=29)

Model	Dependent variable	Independent variable	*B*	*SE B*	β	*t*	*p value*
Step 1		**(Constant)**	**-20.809**	**14.385**		**-1.447**	**.160**
	Parent rated SCAS (total)	**Age (years)**	**.897**	**.374**	**2.397***	**.024***	
		SRS (total)	**2.151**	**.087**	**.492**	**3.149***	**.004***
			.275				
Step 2		**(Constant)**		**20.605**		**.829**	**.415**
		Age (years)	**17.087**	**.884**	**.507**	**3.296***	**.003***
		SRS (total)	**2.913**	**.096**	**.265**	**1.542**	**.136**
		SSP (total)	**.148**	**.115**	**-.436**	**-2.399***	**.024***
			-.277				
Step 3		**(Constant)**		**22.753**			**.674**
		Age (years)	**9.681**	**.910**	**.533**	**.425**	**.003***
		SRS (total)	**3.060**	**.097**	**.256**	**3.364***	**.153**
		SSP (total)	**.143**	**.118**	**-.461**	**1.475**	**.020***
		NEPSY (total)	**-.293**	**1.208**	**.118**	**-2.482***	**.434**
			.960				
						.795	

***p < .05**

From the above table, in step 1 age and autism severity are significant predictors of anxiety. When SSP was entered in step 2, sensory processing was found to significantly predict anxiety. Autism severity is no longer a significant predictor in step 2. Age remains as a significant predictor in this model. In step 3, age and sensory processing continue to be significant predictors for this model. EF does not make a significant contribution. The effect size (f^2) for the final model is 0.263 which is medium to large effect size. The observed power for the final model is 0.457

b. Predicting anxiety in Reverse Hierarchical order of anxiety predictors

The above model was repeated with EF and SSP reversed in terms of order of entry. The following table (table 4.18), shows results of this analyses.

Table 4.18

Summary of fitness of regression model for predictors of heightened anxiety in ASD (N=29)

Model	Dependent variable	Independent variable	R	R^2	ΔR^2	Durbin-Watson	F	p value
Step 1	**Parent rated SCAS**	**(Constant) Age (years) SRS (total)**	**.606**	**.367**	**.318**		**7.534**	**.003***
Step 2		**(Constant) Age (years) SRS (total) NEPSY (total)**	**.608**	**.370**	**.294**		**4.890**	**.008***
Step 3		**(Constant) Age (years) SRS (total) NEPSY (total) SSP (total)**	**.706**	**.499**	**.415**	**1.907**	**5.965**	**.002***

***p < .05**

EF is contributing a small amount to the variance in anxiety. The following table shows summary of contribution of each individual variables to this regression model (Table 4.19).

Table 4.19

Summary of contribution of individual variable to regression model predicting anxiety (N=29)

Model	Dependent variable	Independent variable	*B*	*SE B*	β	*t*	*p value*
Step 1		**(Constant)**	**-**	**14.385**		-1.447	**.160**
	Parent	**Age (years)**	**20.809**	**.897**	.374	2.397*	**.024***
	rated SCAS	**SRS (total)**	**2.151**	**.087**	.492	3.149*	**.004***
	(total)		**.275**				
Step 2		**(Constant)**		**19.632**		-1.287	**.210**
		Age (years)	**-**	**.932**	.383	2.381*	**.025***
		SRS (total)	**25.264**	**.089**	.494	3.105*	**.005***
		NEPSY	**2.198**	**1.307**	.055	.341	**.735**
		(total)	**.276**				
Step 3			**.445**	**22.753**		.425	**.674**
		(Constant)		**.910**	.533	3.364*	**.003***
		Age (years)	**9.681**	**.097**	.256	1.475	**.153**
		SRS (total)	**3.060**	**1.208**	.118	.795	**.434**
		NEPSY	**.143**	**.118**	-.461	-	**.020***
		(total)	**.960**			2.482*	
		SSP (total)	**-.293**				

***p < .05**

The above results indicates that age and autism severity are significant predictors of anxiety in step one. When NEPSY was entered in step 2, it did not contribute to the variance in anxiety. In step 3, autism severity is no longer a significant predictors. Age remains as a significant predictor in this model together with SSP. The effect size (f^2) for the final model is 0.263 which is medium to large effect size. The observed power for the final model is 0.457.

c. Predicting anxiety (child rated anxiety) from Sensory Processing and Executive Dysfunctions

Another three stage hierarchical multiple regression was conducted in order to examine predictors of anxiety utilizing the child rated SCAS. The other independent variables are the same as the above model (age, autism severity, executive functioning and sensory processing).

Prior to interpreting the main outcome of the hierarchical multiple regression, the fitness of the regression model was assessed using the Model Summary and ANOVA tables from SPSS. Table 4.20 shows the data of this analyses.

Table 4.20

Summary of fitness of regression model for predictors of heightened anxiety (N=29)

Model	Dependent variable	Independent variable	R	R^2	ΔR^2	Durbin–Watson	F	P value
Step 1		**(Constant)**	**.131**	**.017**	**-.058**		**.226**	**.799**
	Child rated	**Age (years)**						
	SCAS	**SRS (total)**						
Step 2	**(total)**	**(Constant)**	**.132**	**.018**	**-.100**		**.148**	**.930**
		Age (years)						
		SRS (total)						
		SSP (total)						
Step 3		**(Constant)**	**.242**	**.058**	**-.099**	**1.851**	**.372**	**.826**
		Age (years)						
		SRS (total)						
		SSP (total)						
		NEPSY						
		(total)						

The following table shows summary of contribution of each individual variable to this regression model (Table 4.21).

Table 4.21

Summary of contribution of individual variable to regression model predicting anxiety (N=29)

Model	Dependent variable	Independent variable	*B*	*SE B*	β	*t*	*p value*
Step 1		**(Constant)**	**23.322**	20.090		1.161	**.256**
	Child rated SCAS (total)	**Age (years)**	**.781**	1.253	.121	.623	**.538**
		SRS (total)	**.034**	.122	.054	.278	**.783**
Step 2		**(Constant)**	**20.859**	31.911		.654	**.519**
		Age (years)	**.731**	1.369	.114	.534	**.598**
		SRS (total)	**.042**	.149	.067	.283	**.779**
		NEPSY (total)	**.018**	.179	.025	.101	**.921**
Step 3							
		(Constant)	**6.260**	34.949		.179	**.859**
		Age (years)	**1.021**	1.397	.159	.731	**.472**
		SRS (total)	**.032**	.149	.051	.216	**.831**
		NEPSY	**-.014**	.181	-.019	-.076	**.940**
		(total)	**1.893**	1.855	.208	1.020	**.318**
		SSP (total)					

As expected, we can see from the above table that none of the variables predicts anxiety in this model. The effect size (f^2) for the final model is 0.043 which is small effect size. The observed power for the final model is 0.102.

a. Predicting anxiety in Reverse Hierarchical order of anxiety predictors

The following table shows summary of contribution of each individual variables to this regression model (Table 4.22).

Table 4.22

Summary of fitness of regression model for predictors of heightened anxiety (N=29)

Model	Dependent variable	Independent variable	R	R^2	ΔR^2	Durbin-Watson	F	p value
Step 1	**Child rated SCAS (total)**	**(Constant) Age (years) SRS (total)**	**.131**	**.017**	**-.058**		**.226**	**.799**
Step 2		**(Constant) Age (years) SRS (total) NEPSY (total)**	**.241**	**.058**	**-.055**		**.514**	**.676**
Step 3		**(Constant) Age (years) SRS (total) NEPSY (total) SSP (total)**	**.242**	**.058**	**-.099**	**1.851**	**.372**	**.826**

Table 4.23

Summary of contribution of individual variable to regression model predicting anxiety (N=29)

Model	Dependent variable	Independent variable	*B*	*SE B*	β	*t*	*p value*
Step 1		**(Constant)**	**23.322**	20.090		1.161	**.256**
	Child rated SCAS (total)	**Age (years)**	**.781**	1.253	.121	.623	**.538**
		SRS (total)	**.034**	.122	.054	.278	**.783**
Step 2		**(Constant)**	**4.615**	26.903		.172	**.865**
		Age (years)	**.980**	1.265	.152	.775	**.446**
		SRS (total)	**.038**	.122	.062	.316	**.755**
		NEPSY (total)	**1.869**	1.791	.205	1.043	**.307**
Step 3		**(Constant)**	**6.260**	34.949		.179	**.859**
		Age (years)	**1.021**	1.397	.159	.731	**.472**
		SRS (total)	**.032**	.149	.051	.216	**.831**
		NEPSY (total)	**1.893**	1.855	.208	1.020	**.318**
		SSP (total)	**-.014**	.181	-.019	-.076	**.940**

From the above table, none of the variables predicts anxiety in this model. The effect size (f^2) for the final model is 0.043 which is small effect size. The observed power for the final model is 0.102.

b. Exploratory analyses-Predicting Anxiety subtypes from Sensory Processing and Executive Dysfunctions

Findings from our correlational analyses suggests that there is a significant relationship between Separation Anxiety on the parent rated SCAS and sensory

processing. Further examination of relationship between specific anxiety subtypes and EF indicates that the Panic/Agoraphobia was significantly correlated with EF difficulties. Therefore, the next logical step is to ascertain the predictors of these anxiety subscales in relation to executive and sensory processing dysfunctions through Hierarchical Regression Analysis.

In this analysis, the same model as above was adopted. In the first stage of analysis, the Separation anxiety subscale on the parent rated SCAS was entered as dependent variable

Prior to interpreting the main outcome of the hierarchical multiple regression, the fitness of the regression model was assessed using the Model Summary and ANOVA tables from SPSS. Table 4.24 shows summary of the data of these analyses.

Table 4.24

Summary of fitness of regression model for predictors Separation Anxiety (N=29)

Model	Dependent variable	Independent variable	R	R^2	ΔR^2	Durbin-Watson	F	P value
Step 1		**(Constant)**	**.512**	**.262**	**.205**		**4.613***	**.019***
	Separation	**Age (years)**						
	Anxiety	**SRS (total)**						
Step 2	**Subscale-**	**(Constant)**	**.606**	**.367**	**.292**		**4.841***	**.009***
	Parent	**Age (years)**						
	rated	**SRS (total)**						
	SCAS	**SSP (total)**						
Step 3	**(total)**	**(Constant)**	**.639**	**.409**	**.310**	**2.134**	**4.148***	**.011***
Age (years)								
		SRS (total)						
		SSP (total)						
		NEPSY						
		(total)						

***p < .05**

The following table shows summary of contribution of each individual variable to this regression model (Table 4.25).

Table 4.25

Summary of Hierarchical Regression Analysis for Variables predicting Separation Anxiety (N=29)

Model	Dependent variable	Independent variable	*B*	*SE B*	β	*t*	*p value*
Step 1		**(Constant)**	**-2.550**	**3.982**		**-.640**	**.528**
	Separation	**Age (years)**	**.108**	**.248**	**.074**	**.436**	**.666**
	Anxiety-	**SRS (total)**	**.073**	**.024**	**.510**	**3.021***	**.006***
	Parent						
Step 2	**rated SCAS**	**(Constant)**	**6.622**	**5.856**		**1.131**	**.269**
	(total)	**Age (years)**	**.293**	**.251**	**.199**	**1.166**	**.255**
		SRS (total)	**.042**	**.027**	**.295**	**1.550**	**.134**
		SSP (total)	**-.067**	**.033**	**-.411**	**-2.042**	**.052**
Step 3		**(Constant)**	**3.263**	**6.334**		**.515**	**.611**
		Age (years)	**.359**	**.253**	**.244**	**1.420**	**.169**
		SRS (total)	**.040**	**.027**	**.279**	**1.483**	**.151**
		SSP (total)	**-.074**	**.033**	**-.456**	**-2.262***	**.033***
			.435	**.336**	**.209**	**1.295**	**.208**
		NEPSY (total)					

***p < .05**

In step 1, we can see that autism severity is a significant predictor of separation anxiety. When sensory processing was added to the model (step 2), none of the variables significantly predict separation anxiety. At step three NEPSY was added. When all the variables were combined at step 3, sensory processing was a significant predictor for separation anxiety (t=-2.262, p=.033). The effect size (f^2) for the final model is 0.249 which is medium to large effect size. The observed power for the final model is 0.436.

c. Predicting separation anxiety in Reverse Hierarchical order of predictors

The above model was repeated on the reversal order in terms of their independent variable in block 2 and 3.

Table 4.26

Summary of fitness of regression model for predictors of Separation Anxiety (N=29)

Model	Dependent variable	Independent variable	R	R^2	ΔR^2	Durbin-Watson	F	P value
Step 1	**Separation Anxiety Subscale-**	**(Constant) Age (years) SRS (total)**	**.512**	**.262**	**.205**		**4.613***	**.019***
Step 2	**Parent rated SCAS (total)**	**(Constant) Age (years) SRS (total) EF (total)**	**.532**	**.283**	**.197**		**3.285***	**.037***
Step 3		**(Constant) Age (years) SRS (total) EF (total) (Constant)**	**.639**	**.409**	**.310**	**2.134**	**4.148***	**.011***

***p < .05**

The following table shows summary of contribution of each individual variables to this regression model (Table 4.27).

Table 4.27

Summary of Hierarchical Regression Analysis for Variables predicting Separation Anxiety (N=29)

Model	Dependent variable	Independent variable	*B*	*SE B*	β	*t*	*p value*
Step 1		**(Constant)**	**-2.550**	**3.982**		**-.640**	**.528**
	Separation	**Age (years)**	**.108**	**.248**	**.074**	**.436**	**.666**
	Anxiety	**SRS (total)**	**.073**	**.024**	**.510**	**3.021***	**.006***
	subscale -						
Step 2	**Parent**	**(Constant)**	**-5.601**	**5.370**		**-1.043**	**.307**
	rated SCAS	**Age (years)**	**.141**	**.253**	**.096**	**.558**	**.582**
	(total)	**SRS (total)**	**.074**	**.024**	**.515**	**3.034***	**.006***
		NEPSY	**.305**	**.357**	**.146**	**.852**	**.402**
		(total)					
Step 3		**(Constant)**	**3.263**	**6.334**		**.515**	**.611**
		Age (years)	**.359**	**.253**	**.244**	**1.420**	**.169**
		SRS (total)	**.040**	**.027**	**.279**	**1.483**	**.151**
		NEPSY(total)	**.435**	**.336**	**.209**	**1.295**	**.208**
		SSP (total)	**-.074**	**.033**	**-.456**	**-2.262***	**.033***

***p < .05**

From the above table, in step 1, ASD severity is a significant predictors to separation anxiety. When NEPSY was entered in step 2, ASD severity remains as a significant predictor of separation anxiety. Executive function does not the influence in the variance in separation anxiety in this model. When everything was combined together in step 3, ASD severity is no longer a significant predictor. In this step, sensory processing became significant predictor of Separation anxiety over and above other variables (β=.533, t=2.262, p=.033). The effect size (f^2) for the final model is 0.249 which is medium to large effect size. The observed power for the final model is 0.436.

d. Predicting Panic and Agoraphobia from EF and SP dysfunctions

In our study, we have found that Panic and Agoraphobia subscale of the SCAS-P was correlated with the total score of the NEPSY and SSP. It is rather unexpected as so far there is no evidence of these relationship found in literature. Therefore, we would like to further explore the predictors of Panic and Agoraphobia using Hierarchical Regression Analysis.The results of this analysis are as per table 4.28 below.

Table 4.28

Summary of fitness of regression model for predictors of Panic and Agoraphobia (N=29)

Model	Dependent variable	Independent variable	R	R^2	ΔR^2	Durbin-Watson	F	P value
Step 1	**Panic and Agoraphobia (Parent rated SCAS)**	**(Constant) Age (years) SRS (total)**	**.528**	**.279**	**.224**		**5.037**	**.014***
Step 2		**(Constant) Age (years) SRS (total) SSP (total)**	**.678**	**.460**	**.395**		**7.087**	**.001***
Step 3		**(Constant) Age (years) SRS (total) SSP (total) NEPSY (total)**	**.711**	**.506**	**.423**	**1.669**	**6.134**	**.002***

***p < .05**

The following table shows summary of contribution of each individual variables to this regression model (Table 4.29).

Table 4.29

Summary of Hierarchical Regression Analysis for Variables predicting Panic and Agoraphobia (N=29)

Model	Dependent variable	Independent variable	*B*	*SE B*	β	*t*	*p value*
Step 1		**(Constant)**	**-5.580**	**3.274**		**-1.704**	**.100**
	Panic and	**Age (years)**	**.559**	**.204**	**.456**	**2.736**	**.011***
	agoraphobia	**SRS (total)**	**.034**	**.020**	**.287**	**1.720**	**.097**
	subscale-						
Step 2	**Parent rated**	**(Constant)**	**4.396**	**4.504**		**.976**	**.338**
	SCAS (total)	**Age (years)**	**.759**	**.193**	**.620**	**3.639**	**.001***
		SRS (total)	**.001**	**.021**	**.007**	**.039**	**.970**
		SSP (total)	**-.073**	**.025**	**-.538**	**-2.888**	**.008***
Step 3		**(Constant)**	**7.342**	**4.820**		**1.523**	**.141**
		Age (years)	**.701**	**.193**	**.572**	**3.639**	**.001***
		SRS (total)	**.003**	**.021**	**.024**	**.137**	**.892**
		SSP (total)	**-.066**	**.025**	**-.491**	**-2.658**	**.014***
		NEPSY (total)	**-.382**	**.256**	**-.220**	**-1.493**	**.148**

***p < .05**

From the above table, in step 1 age is significant predictor to panic and agoraphobia. When SSP was entered at step 2, it becomes a significant predictor for this model. In step 2 age remains as significant predictor, together with sensory processing. When everything was combined at step 3, age and sensory processing remains significant predictors for this model. EF does not significantly contribute to the model. The effect size (f^2) for the final model is 0.459 which is medium to large effect size. The observed power for the final model is 0.720.

a. Predicting Panic and Agoraphobia in Reverse Hierarchical order of EF and SP dysfunctions

The above model was repeated in reverse order in terms of the independent variables in block 2 and 3.

Table 4.30

Summary of fitness of regression model for predictors of Panic and Agoraphobia (N=29)

Model	Dependent variable	Independent variable	R	R^2	ΔR^2	Durbin–Watson	F	P value
Step 1	**Panicand**	**(Constant)**	**.528**	**.279**	**.224**		**5.037**	**.014***
	Agoraphobia	**Age (years)**						
	(Parent rated	**SRS (total)**						
Step 2	**SCAS)**	**(Constant)**	**.600**	**.360**	**.283**		**4.686**	**.010***
		Age (years)						
		SRS (total)						
		SSP (total)						
Step 3		**(Constant)** **.002***	**.711**	**.506**	**.423**	**1.669**	**6.134**	
		Age (years)						
		SRS (total)						
		SSP (total)						
		NEPSY						
		(total)						

***p < .05**

The following table shows summary of contribution of each individual variables to this regression model (Table 4.31).

Table 4.31

Summary of Hierarchical Regression Analysis for Variables predicting panic and agoraphobia (N=29)

Model	Dependent variable	Independent variable	*B*	*SE B*	β	*t*	*p value*
Step 1	**Panic and agoraphobia subscale Parent rated**	**(Constant)**	**-5.580**	**3.274**		**-1.704**	**.100**
		Age (years)	**.559**	**.204**	**.456**	**2.736***	**.011***
		SRS (total)	**.034**	**.020**	**.287**	**1.720**	**.097**
Step 2	**SCAS (total)**	**(Constant)**	**-.586**	**4.221**		**-.139**	**.891**
		Age (years)	**.505**	**.198**	**.413**	**2.547***	**.017***
		SRS (total)	**.033**	**.019**	**.276**	**1.725**	**.097**
		NEPSY (total)	**-.499**	**.281**	**-.287**	**-1.775**	**.088**
		Age (years)	**.701**	**.193**	**.572**	**3.639***	**.001***
		SRS (total)	**.003**	**.021**	**.024**	**.137**	**.892**
		NEPSY (total)	**-.382**	**.256**	**-.220**	**-1.498**	**.148**
		SSP (total)	**-.066**	**.025**	**-.491**	**2.658***	**.014***

***p < .05**

From the above table, in step 1 age is a significant predictor to panic and agoraphobia. When NEPSY was added in step 2, it did not contribute to the variance in anxiety as age remains as significant predictor for this model. In step 3, age and sensory processing was found as significant predictors for panic and agoraphobia. The effect size (f^2) for the final model is 0.459 which is medium to large effect size. The observed power for the final model is 0.720.

b. Predicting Generalized Anxiety Disorder (GAD) from EF and SP dysfunctions

In our study, we have also found that GAD subscale of the SCAS-P was correlated with the total score of the SSP. Therefore, we would like to further explore the predictors of GAD using Hierarchical Regression Analysis.

The same model was adopted as above and in this analysis only the parent report SCAS was used. The results of this analysis are as per table 4.32 and 4.33 below.

Table 4.32

Summary of fitness of regression model for predictors of GAD (N=29)

Model	Dependent variable	Independent variable	R	R^2	ΔR^2	Durbin-Watson	F	P value
Step 1	**GAD subscale**	**(Constant) Age (years) SRS (total)**	**.489**	**.239**	**.181**		**4.091**	**.029***
Step 2	**(Parent rated SCAS)**	**(Constant) Age (years) SRS (total) SSP (total)**	**.630**	**.397**	**.325**		**5.488**	**.005***
Step 3		**(Constant) Age (years) SRS (total) SSP (total) NEPSY (total)**	**.640**	**.410**	**.312**	**1.608**	**4.168**	**.011***

***p < .05**

The following table shows summary of contribution of each individual variables to this regression model (Table 4.33).

Table 4.33

Summary of Hierarchical Regression Analysis for Variables predicting Panic and Agoraphobia (N=29)

Model	Dependent variable	Independent variable	*B*	*SE B*	β	*t*	*p value*
Step 1	**GAD subscale-Parent rated SCAS (total)**	**(Constant)**	**-1.794**	**2.949**		**-.608**	**.548**
		Age (years)	**.227**	**.184**	**.211**	**1.232**	**.229**
		SRS (total)	**.047**	**.018**	**.450**	**2.630**	**.014***
Step 2		**(Constant)**	**6.385**	**4.172**		**1.531**	**.138**
		Age (years)	**.391**	**.179**	**.364**	**2.186**	**.038***
		SRS (total)	**.020**	**.019**	**.189**	**1.014**	**.320**
		SSP (total)	**-.060**	**.023**	**-.503**	**-2.557**	**.017***
Step 3		**(Constant)**	**5.018**	**4.617**		**1.087**	**.288**
		Age (years)	**.418**	**.185**	**.389**	**2.267**	**.033***
		SRS (total)	**.019**	**.020**	**.180**	**.954**	**.349**
		SSP (total)	**-.063**	**.024**	**-.528**	**-2.619**	**.015***
		NEPSY (total)	**.177**	**.245**	**.116**	**.723**	**.447**

***p < .05**

From the above table, in step 1 ASD severity is significant predictor to GAD. When SSP was entered at step 2, age and sensory processing becomes a significant predictor, whilst ASD severity is no longer a significant predictor for this model. At step 3, age and sensory processing remain significant predictors for this model. EF does not significantly contribute to the model. The effect size (f^2) for the final model is 0.290 which is medium to large effect size. The observed power for the final model is 0.499.

b. Predicting GAD in Reverse Hierarchical order of EF and SP dysfunctions

The above model was repeated on reversal order in terms of their independent variable in block 2 and 3. The results of this analysis are as per table 4.34 and 4.35 below.

Table 4.34

Summary of fitness of regression model for predictors of GAD (N=29)

Model	Dependent variable	Independent variable	R	R^2	ΔR^2	Durbin-Watson	F	P value
Step 1	**GAD (Parent rated SCAS)**	**(Constant) Age (years) SRS (total)**	**.489**	**.239**	**.181**		**4.091**	**.029***
Step 2		**(Constant) Age (years) SRS (total) NEPSY (total)**	**.481**	**.241**	**.150**		**2.650**	**.071**
Step 3		**(Constant) Age (years) SRS (total) NEPSY (total) SSP (total)**		**.640**	**.410**	**.312**	**1.608**	**4.168**	**.011***

***p < .05**

The following table shows summary of contribution of each individual variable to this regression model (Table 4.35).

Table 4.35

Summary of Hierarchical Regression Analysis for Variables predicting GAD (N=29)

Model	Dependent variable	Independent variable	*B*	*SE B*	β	*t*	*p value*
Step 1	**GAD subscale-Parent rated SCAS (total)**	**(Constant)**	**-1.794**	**2.949**		**-.608**	**.548**
		Age (years)	**.227**	**.184**	**.211**	**1.232**	**.229**
		SRS (total)	**.047**	**.018**	**.450**	**2.630**	**.014***
Step 2		**(Constant)**	**6.385**	**4.172**		**1.531**	**.138**
		Age (years)	**.391**	**.179**	**.364**	**2.186**	**.038***
		SRS (total)	**.020**	**.019**	**.189**	**1.014**	**.320**
		NEPSY (total)	**-.060**	**.023**	**-.503**	**-2.557**	**.017***
Step 3		**(Constant)**	**5.018**	**4.617**		**1.087**	**.288**
		Age (years)	**.418**	**.185**	**.389**	**2.267**	**.033***
		SRS (total)	**.019**	**.020**	**.180**	**.954**	**.349**
		NEPSY (total)	**.177**	**.245**	**.116**	**.723**	**.447**
		SSP (total)	**-.063**	**.024**	**-.528**	**-2.619**	**.015***

***p < .05**

From the above table, in step 1 ASD severity is significant predictor of GAD. When NEPSY was entered at step 2, executive dysfunctions becomes a significant predictor for this model. In step 2 age remains as significant predictor. When everything was combined at step 3, age and sensory processing are significant predictors of GAD. EF does not significantly contribute to the model. The effect size (f^2) for the final model is 0.290 which is medium to large effect size. The observed power for the final model is 0.499.

f. Relationship between the NEPSY subtests and Panic and Agoraphobia subscale of parent rated SCAS

Airaksinen et al. (2005) indicated that panic disorder with and without agoraphobia, and obsessive–compulsive disorder were related to impairments in both episodic memory and executive functioning. However, this finding is

from a population-based sample. In the correlational analyses, we have found that the Panic and agoraphobia subscale of parent rated SCAS was correlated with the total score of NEPSY. Results from our regression analyses suggests that the amount of GAD are affected by SP atypicalities. Therefore, we would like to explore whether is there any EF subtests that specifically relates to Panic/Agoraphobia. In order to explore this relationship, total score of all NEPSY subtests and total score of GAD subscale of parent rated SCAS were subjected to correlational analyses. Table 4.36 shows results of this analyses.

Table 4.36

Correlations between NEPSY subtests and Panic and Agoraphobia subscale of parent rated SCAS

Variable 1	Variable 2	r	p value
Animal Sorting (total, N=35)	Panic and	-.075	.687
Auditory Attention (total, N=34)	Agoraphobia	-.304	.096
Response Set (total, N=34)	Subscale of	-.147	.431
Clock (total, N=34)	parent rated	-.081	.666
Design Fluency (total, N=34)	SCAS (total),	-.212	.252
Inhibition-Naming (total, N=34)	N=34	-.323	.077
Inhibition-Inhibition(total, N=34)		-.266	.149
Inhibition-Switching(total, N=35)		-.342	.059

The above findings indicate that there are no significant relationship between EF subtests and Panic and Agoraphobia subscale of parent rated SCAS.

g. Relationship between NEPSY subtests and GAD subscale of parent rated SCAS

In our study, we have also found that the GAD subscale of the SCAS-P was correlated with the total score of SSP, whereas no relationship was found between GAD and total score of NEPSY. We also found that SP is better predictor of GAD compared to EF. We are interested in exploring whether there is some association being 'held' at certain EF subtests using correlation analysis. Therefore, the total score of EF subtests and total score of GAD subscale of SCAS-P was subjected to correlation analysis.

Table 4.37

Correlations between NEPSY subtests and GAD subscale of parent rated SCAS

Variable 1	Variable 2	r	p value
Animal Sorting (total, N=35)	Generalized	.055	.763
Auditory Attention (total, N=34)	anxiety	-.090	.622
Response Set (total, N=34)	Subscale of	-.050	.785
Clock (total, N=34)	parent rated	.124	.498
Design Fluency (total, N=34)	SCAS (total)	.195	.286
Inhibition-Naming (total, N=34)	N=34	.075	.685
Inhibition-Inhibition (total, N=34)		-.099	.588
Inhibition-Switching (total, N=35)		-.013	.946

The above findings indicate that there are no significant relationship between EF subtests and GAD subscale of parent rated SCAS.

4.4 Discussion

4.4.1 Overview

In this study, we are interested in determining the relationships between executive functions and sensory processing atypicalities in relation to anxiety in children with ASD. The following section will discuss the findings of our main analyses as well as exploratory analyses.

a. Relationship between anxiety and EF

Unlike Hollock et al (2014) who suggests that there is relationship between EF and anxiety in ASD. We found little evidence for this relationship in our sample. Similarly, in contrast to Zandt et al. (2009) who report a relationship between OCD and EF, our results indicate that there is no such relationship in our sample. This finding is therefore not consistent with studies which suggest that OCD is commonly associated with mild cognitive dysfunction on tasks involving executive functioning (e.g. Greisberg & McKay, 2003; Kuelz, Hohagen & Voderholzer, 2004a). Airaksinen et al. (2005) examined whether persons diagnosed with an anxiety disorder show neuropsychological impairments relative to healthy controls. In their study (*ibid*) executive functioning was measured by the Trail Making Test-B (Reitan, 1959; Reitan and Davidson, 1974), which was impaired in panic disorder with and without agoraphobia group, and obsessive-compulsive disorder group. Our findings also indicate that there is a relationship between Panic/Agoraphobia on the parent rated SCAS and Executive dysfunctions. This is the first study that has found this relationship in children with autism. Furthermore, Eysenck et al., (2007) indicates that anxiety disrupts the balance between the top-down attentional control and bottom up stimulus driven attentional systems (Corbetta and Shulman, 2002). These could maybe explain why autistic children with Panic Disorder have difficulties with EF functions.

b. Relationship between anxiety and SP

Literature findings indicate that there is a relationship between anxiety and sensory atypicalities in ASD (Lidstone et al., 2014, Wigham et al., 2014, Mazurek et al., 2013, Green & Ben-Sasson, 2010, Ben-Sasson et al., 2008 & Pfeiffer et al., 2005). Results of the current study support these previous findings indicating that there is a significant correlation between sensory processing difficulties as rated by parents and parent but not child reported anxiety and also that SP atypicalities predict parent rated anxiety.

Previous studies show that SP dysfunctions are correlated with greater social impairment (Miller et al., 2005) and poor social performance (Baker et al., 2008). Therefore, whilst exploring all of the anxiety subscales in relation to SP we specifically predicted an association between Social Phobia and SP difficulties. Findings, however indicated no significant correlation between social phobia and SP, rather our data indicates that Separation Anxiety, Panic/Agoraphobia and Generalized anxiety were correlated with SP. These findings have not been reported elsewhere.

c. The Relationship between specific EF subtests, anxiety and SP

Previous literature has shown that children with ASD and OCD tended to demonstrate impairments on a task requiring inhibition (Zandt et al., 2009). Greisberg and McKay (2003) examined neuropsychological features of OCD and found deficits in organizational strategies. However our findings indicate that there is no relationship between planning and organization and anxiety in our sample

This finding is unexpected, but literatures have already pointed that SP dysfunctions are related to anxiety, social relationship, communication disturbances, self-absorption and antisocial behaviours (Liss et al. 2006). On this account, hypersensitivity in autism results from an imbalance in inhibitory and excitatory connectivity between local neural networks in sensory regions.

Hallet et al., (2013) point out that it still remains unclear whether anxiety difficulties constitute a separate condition or align closely with core ASD features. Our findings indicate that anxiety aligns closely with core ASD features particularly sensory atypicalities. A first hand account of SP atypicalities was postulated by Williams (1994), who suggests that sensory overload makes autistic individuals react as if they are being attacked or bombarded, resulting in such physical symptoms as headaches, anxiety, panic attacks or aggression. Pellicano and Burr (2012) propose that people with autism see the world more accurately – as it really is – as a result of being less biased by prior experiences.

They suggest that it is not sensory processing itself that is different in autism, but the interpretation of sensory input to yield perception. They further proposed that Bayesian models can be applied to autism to pinpoint fundamental differences in perceptual mechanisms. Specifically, they found that atypicalities in the use of priors resulting in attenuated or of 'hypo-priors' might explain the broad range of sensory and other non-social atypicalities in autism. Following that, Pellicano (2013) reviewed existing theoretical accounts of autism and provides an overview of a new theoretical account which may explain the range and idiosyncrasy of sensory sensitivities and difficulties dealing with new experiences which leads to anxiety in ASD.

Bayesian models do provide a principled way of thinking about visual perception in autism. However, since this is a new perspective on the perceptual mechanism in autism, much work remains to be done to provide evidence to support this theoretical perspective. Teufel et al., (2013) argued that in that respect, there are fundamental technical and conceptual problems which must be addressed if such a view is to become useful. Some of the examples of the model that has been provided by Pellicano and Burr (2012) are vulnerable to empirical criticism (Teufel et al., 2013). This is particularly in providing full mathematical formalizations of specific, isolated symptoms in autism (*ibid*).

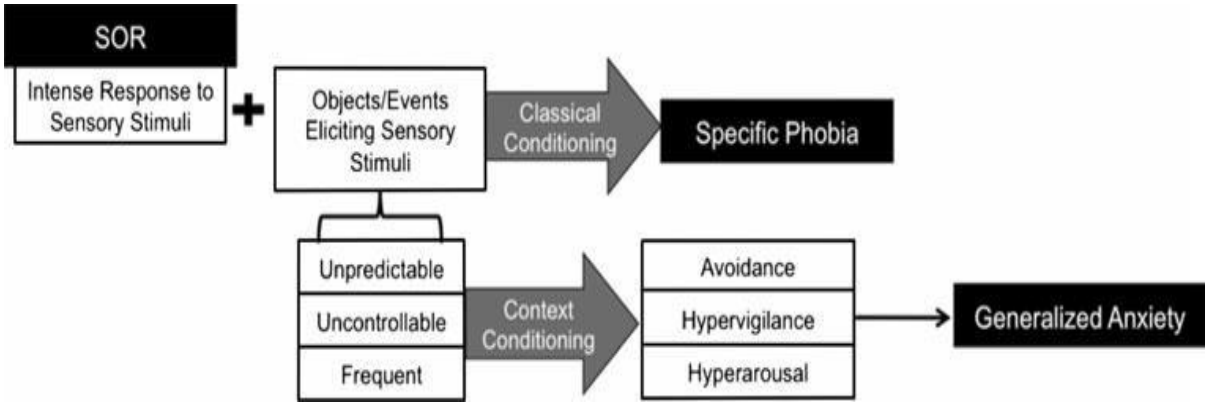
d. Predicting anxiety from EF and SP dysfunctions

In this study using regression analyses, we explored predictors of anxiety and we have found that increasing age and the presence of a higher level of sensory processing atypicalities were predictors of parent rated anxiety.

Green and Sasson (2010) proposed three possible theories to explain the association between anxiety and Sensory Over-Responsivity (SOR): (a) SOR is caused by anxiety; (b) Anxiety is caused by SOR; or (c) SOR and anxiety are causally unrelated but are associated through a common risk factor or diagnostic overlap. The findings of this study, therefore support the second theory that anxiety is caused by sensory over-responsivity (SOR) or sensory processing dysfunctions.

In order to understand the association that anxiety is caused by SOR, they have introduced a Primary SOR model which is as per figure 4.1 below.Figure 4.1

Primary SOR model portraying the theoretical pathway from symptoms of sensory over-responsivity to anxiety disorders (Green and Sasson, 2010).



The above model suggests that unpleasant sensory stimuli (the unconditioned stimuli, such as an aversive noise) are associated with certain objects or situations. Consequently, these objects become conditioned stimuli, capable of eliciting a conditional response, such as fear or anxiety. However, conditioning is also a mechanism through which SOR might lead to more generalized anxiety through what is called context conditioning (Grillon, 2008).

Through context conditioning, the conditional fear response can shift from being actuated by a specific object to a position or context in which the aversive stimulus has passed. Autistic children with SOR often become avoidant of generalized locations such as restaurants, grocery stores, or parties in addition to specific objects (Schoen et al. 2008). The more generalized the avoidance, the more impaired the child is likely to be.

Therefore, the primary SOR model has explained exactly the role of SOR in the development of anxiety. Nevertheless, this model still needs further investigation as, by definition, SOR is a fearful reaction, but fear alone does not imply an anxiety disorder (Green and Sasson, 2010). Context conditioning is more characteristic of anxiety than fear. Furthermore, Lane et al. (2010) explored the

relationship between sensory overresponsivity (SOR) and anxiety in children with autism, attention deficit hyperactivity disorder, and typical development using both physiological and behavioural data. Results showed that the strength or magnitude of sensory responsivity mediates the relationship between baseline arousal and attention and resultant anxiety and physiologic recovery from sensory challenge. Behavioural tools used to measure SOR do not reflect physiological responsiveness which indicate a mismatch and warrants further investigation.

e. Predicting specific anxiety types from EF and SP dysfunctions

A meta-analysis of 31 studies conducted by van Steensel et al., (2011) found that the most common anxiety diagnoses are specific phobia (30%), Obsessive Compulsive Disorder (OCD; 17%) and generalized anxiety (15%). In terms of specific anxiety subscales, OCD has been found to correlate with EF difficulties (Zandt et al., 2009) and social phobia was highly related with SP atypicalities (Bellini, 2006). We did not replicate these findings here. In our correlation analysis, we have found that there are relationships between separation anxiety and SP.

A further exploratory analysis was undertaken to explore the hypothesis that separation anxiety is predicted by EF or SP. The regression analyses indicated that older age and sensory processing atypicalities are significant predictors of parent rated separation anxiety whilst EF makes no contribution. In addition, in our regression model, initially when autism severity was combined with age, autism severity was a stronger predictor of separation anxiety. However, when EF was added to the model, it was found that the amount of anxiety was affected more by the ASD severity than age and EF difficulties. This finding may suggests that EF is probably overlapping or interwoven with the core characteristic of autism as captured by our ASD severity measure, the SRS.

We also explored predictors of panic and agoraphobia and found that sensory processing is a significant predictor of parent rated panic. This could perhaps relate to the nature and the way panic is expressed. For example, when a child is exposed to sensory stimuli they may become either under-stimulated or over-

stimulated. Which may be due to a deficit in attentional shifting, which has been observed among autistic children when shifting between sensory modalities (Belmonte, 2000) and between object features (e.g. Courchesne, 1994).

The last anxiety subtype that was associated with sensory processing is GAD, our findings indicate that age and amount of SP atypicalities but not EF difficulties, predicted parent rated GAD in children with ASD. This finding further implies that SOR also leads to GAD, which is parallel with the Primary SOR model (Green and Sasson, 2010). The Primary SOR model suggests that conditioning is also a mechanism through which SOR might lead to more generalized anxiety. For instance, if the unconditioned stimulus does not always signal the conditioned stimulus (i.e., aversive noises can occur by chance without being caused by one particular object), the concern is more potential to generalize through what is called context conditioning (Grillon, 2008).The frequency, uncontrollability, and volatility of the conditioned stimuli may then induce the child to become generally hypervigilant to potentially threatening sensory stimuli, and to maintain physiological arousal, resulting in a state of generalized anxiety and worry (Green and Sasson, 2010).

In a study focusing on the emergence of and bidirectional effects between anxiety and SOR in toddlers with ASD, Green et al. (2011) found that SOR positively predicted changes in anxiety. This prediction is over and above child age, autism symptom severity, non-verbal developmental functioning, and maternal anxiety. They also found that anxiety did not predict changes in SOR (*ibid*). Throughout our regression analyses, we have found that increasing age predicted changes in anxiety over and above other variables in children with autism, which is discrepant with the findings by Green et al. (2011). Nevertheless, our result also suggests that SOR predicted changes in anxiety, and presages the later development of anxiety in children with autism.

4.4.2 Strengths, limitations and suggestions for future research

In this study, we present data from a sample of autistic children, with confirmed ASD diagnoses, and use a series of well-validated (in TD) measures of anxiety, EF and SP. This study was the first to examine EF as a possible

neuropsychological correlate of anxiety in ASD together with sensory atypicalities. Against these strengths, a number of limitations should be considered. Firstly, the sample size in this study is small but comparable with other studies that have adopted the same research framework. Our post Hoc power ranged between 0.436 (43.6%) to 0.720 (72 %) indicating that some analyses were underpowered. Effect sizes ranged from 0.263 to 0.459, which represent medium to large effect sizes (Cohen, 1988). This suggests that the impact of age, ASD severity, EF and SP on anxiety are powerful. Therefore although our sample (N=29) is considered small (Green, 1991), medium to large effect sizes were still apparent.

Secondly, the cross-sectional design provides only a snapshot of functioning at a single point only.

Thirdly, the measures used (The NEPSY, SSP and SCAS) were not designed for children with autism. They were developed with typically developing children. For the NEPSY, there are interpretation guidelines provided for use with children with autism that we have followed. On the SCAS, a recent systematic review of the properties of tools used to measure outcomes in anxiety intervention studies for children with ASD found that it is a robust measure for anxiety in children with ASD (Wigham and McConachie 2014).

The SSP has been used widely to assess sensory processing dysfunctions in children ASD (e.g. Lane et al., 2010, Chen et al, 2009, Ben-Sasson et al., 2009, Ashburner et al., 2008, Leekam et al., 2007, Tomchek & Dunn, 2007).

Fourthly, all of our significant findings on correlational and regression analyses are from parent rated measures (Parent rated SCAS and SSP) and we did not find strong agreement between child and parent dyads on the SCAS. It is hard to interpret what this lack of agreement means however it is important to note it in the context that the significant findings were largely related to parent rated measures. This could result from common method variance (CMV) problems. Bitsika et al. (2015) examined the relative validity of parent-report and self-report of Generalised Anxiety Disorder (GAD) symptoms in boys with an Autism Spectrum Disorder (ASD). The found that the choice of which source to use

when assessing anxiety in boys with an ASD needs to be referring to parents and their child for different aspects of GAD rather than just to parents. It is also suggested that boys with an ASD might be the most reliable index of the severity of the two key symptoms of GAD (being worried and being unable to control those worries). These results therefore challenge the practice of collecting total GAD scores about boys with an ASD solely from their parents.

Lindell and Whitney (2001) pointed that cross-sectional studies of attitude-behaviour relationships are vulnerable to the inflation of correlations by (CMV) and Common method biases pose a rival explanation for the correlation observed between the measures (Podsakof et al, 2003). Doty and Glick (1998) assessed the level of common methods bias in all multitrait-multimethod correlation matrices published over a 12-year period in a set of six social science journals using a combination of structural equation modelling and meta-analysis. Results indicate that only 46% of the variation in measures is attributable to the constructs, that 32% of the observed variation in measures is attributable to common methods variance, and that common methods variance results in a 26% bias in the observed relationships among constructs. Consequently, the possibility arises that method variance has inflated the observed correlations between our variables artifactually (*ibid*; page, 115).

4

In terms of future work, a follow up study on how anxiety manifests at different points in children's lives will be an important avenue. Anxiety has been consistently associated with older age in this study. Therefore, investigating the development of anxiety over time may help to explain the variability in factors affecting anxiety in children with autism.

As for sample size, Stevens (1999) pointed that "when significance is not found and a post hoc power analysis reveals a large or medium effect size, then it is essential to replicate the study with more adequate sample size" (p. 133). Therefore, replication of this study with a more adequate sample size is recommended.

Future replication studies also should adopt a research framework that addresses the potential biasing effects of method variance in their research, such as providing data from multiple sources, methods or informants.

The potential relationship between executive dysfunctions and repetitive behaviours in relations to specific EF functions is also worthy of further work. Future work also should focus on profiling of executive function and sensory atypicalities across the lifespan. In those children who show no clear executive deficits in test batteries, performance in naturalistic settings involving executive functions, such as in classroom or during play activities will warrant some interesting findings. Future work also should focus on developing a cognitive model of anxiety for children with autism. Finally acknowledgement of the heterogeneity of the profiles of children with ASD is important in future work. This issue will be addressed in future chapters.

4.5 Conclusion

In this study, we have examined the relationships between executive functions and sensory processing in relation to anxiety in a sample of young people with ASD. We utilized a range of test batteries and questionnaires in order to measure anxiety, executive functioning and sensory processing. A series of correlation and regression analyses were utilized to investigate the specific hypotheses for this study. Results indicate that sensory processing dysfunction is associated with anxiety. No relationship was found between EF and total anxiety. Further analysis on anxiety subscales found that there is a relationship between Separation Anxiety, Panic/Agoraphobia and Generalized anxiety were correlated with SP. Further analysis of predictors for Separation anxiety, panic and agoraphobia and also the GAD found that SP has better predictive value for these anxiety subtyptes than EF. The amount of anxiety was also predicted by older age in this group of children with autism.

Chapter 5. The Influence of Executive and Sensory Processing Dysfunctions on Anxiety in ASD – Exploring heterogeneity

5.1 Introduction

5.1.1 Executive Dysfunctions and anxiety

Previous research on anxiety in ASD, suggests that social phobia, social anxiety (Bellini, 2004; 2006) and OCD (Zandt et al., 2007; 2009) are the most consistently occurring specific anxiety problems in this population. Studies examining neuropsychological correlates of anxiety in ASD report impairments in range of neuropsychological domains including attention and EF (e.g. Castaneda et al., 2008). Airaksinen et al. (2005) suggested variability in neuropsychological correlates depending on the specific anxiety disorders being studied. Their analyses on anxiety subgroups indicated that panic disorder with and without agoraphobia and obsessive–compulsive disorders are related to impairments in both episodic memory and executive functioning.

5.1.2 Sensory Processing Dysfunctions and anxiety

SP dysfunction is now considered as part of the core symptoms of ASD in DSM-V (APA, 2014). The relationship between SP dysfunctions and anxiety was already observed in previous chapter (Chapter 4). Therefore, in this chapter, the relationship will be further explored in order to identify variability in terms of symptoms profile (heterogeneity).

ASD is a heterogeneous disorder with considerable diversity or variability in symptom profiles. Autism is perhaps the most classic example of a heterogeneous disorder in which dissimilar parts are somehow connected. Georgiades et al. (2013) suggest that despite the differences in functional qualities, symptom type and severity and also causal factors, autism is still viewed as one entity, with all affected individuals placed within a spectrum of pathology which is autism spectrum disorder. Therefore, a new research

paradigm is needed rather than conducting studies that compare 'autism cases' with 'typically developing individuals' the focus should be on understanding the meaning of individual and subgroup differences within the autism spectrum. Examining within syndrome heterogeneity could also provide a general framework that will guide the development, implementation and interpretation of new study designs and measurements that will have the ability to capture individual and subgroup differences within autism.

Overall, ASD presents with broad variations in phenotypes and severities which further suggests the involvement of multiple predisposing factors which interacting in complex ways (Belmonte et al., 2004). Georgiades et al. (2013) further suggest that these differences will provide informative 'links' between the different levels of autism (phenotype and genotype) and account for a substantial amount of the variability observed in studies of autism causes, diagnosis, treatment and prognosis.

5.1.3 The impact of development (age and IQ) and autism severity on anxiety in ASD

There is also potential impact of development and autism severity on anxiety in ASD. Studies examining phenomenology of anxiety confirm that anxiety is not a rare occurrence. White et al. (2009) reviewed the phenomenology of anxiety and found that there are very likely age and IQ effects on the presentation of anxiety, with younger children experiencing milder anxiety (based on parent-report), and cognitively higher functioning children experiencing more anxiety than children with ASD who are cognitively lower functioning. A few other studies examining anxiety in ASD, have suggested a link between higher intellectual functioning (full scale IQ>70) and elevated levels of anxiety symptoms in ASD (Hallet et.al, 2013 & Sukhodolsky et al., 2008).

In terms of autism severity, stereotyped behaviour and more complex behaviours such as repetitive questioning often increase when children are distressed or anxious, suggesting that these behaviours may act as self-calming strategies for children with autism (Howlin, 1998). Engagement in obsessions and rituals may play a key role in keeping fear and anxiety under control (Howlin, 1997). Prevention or disruption of these behaviours may induce considerable anxiety and distress. As anxiety plays a specific and important role in the difficulties of children with autism, it would be expected that the severity of anxiety in children with autism would exceed levels in the general population (White at al., 2009)

Research on the impact of age on EF dysfunction raises the possibility that differential EF deficits emerge with age and are not present early in the preschool range (Griffith et al, 1999 & Dawson et.al, 2002). Kern et al (2006) found that SP difficulties may improve with age. In another study on SOR and anxiety, Kern et al. (2007b) concluded that multi-sensory disturbance was positively associated with autism severity in children but weakened in adolescents and adults. Green et al. (2011) suggests that anxiety symptoms increased overtime while SOR remained relatively stable. The study also indicates that SOR predicts changes in anxiety over and above the child age and autism severity. Therefore it is important also to explore the potential impact of developmental factors and autism severity on anxiety in order to ascertain whether they contribute to anxiety

Due to the heterogeneity associated with ASD the potential relationship between anxiety and other features associated with ASD, such as EF deficits and sensory processing atypicalities may not be detected at group level, therefore, exploring data at subgroup level is an important step forward. Among one of the first studies to subcategorize ASD using cluster analysis was Stevens et al. (2000). They conducted a longitudinal study on 138 school-age children with ASD in order to identify if subgroups emerged. 2 subgroups emerged marked by different levels of social, language and nonverbal ability. In another study, based on MRI data (Hrdlicka et al. 2005), the clusters obtained were able to show that the children differed significantly in the overall severity of autistic symptomatology. Little et al. (2013), employed cluster analytic technique to explore subgroups of children with Williams Syndrome based on their cognitive and behavioural profiles. The cluster that emerged distinguished variability of social approach

behaviour in Williams Syndrome based on data gathered from experimental tasks and an interview with parents. In another study by Reid (2013), a series of cluster analyses were utilised in order to explore heterogeneity with regard to Attention to Detail (ATD) in ASD. Results suggested that subgroups of children existed characterized by different profiles of ATD and ASD features. Therefore based on the literature findings, cluster analysis is a promising method for studying heterogeneity and subtyping in ASD.

Overall this study aimed to determine whether subgroups of children can be identified within an ASD sample based on their profiles in relation to anxiety, executive functioning and sensory atypicalities, whilst taking into account other developmental characteristics such as age, ability and ASD severity. The specific aims of this study are:

a. To identify subgroups of children with ASD on anxiety, according to their performance on executive functioning task and their SP atypicalities
b. To explore any possible associations between specific anxiety subtypes and ASD specific phenotypic behaviours.

5.2 Methodology

5.2.1 Participants

a. Inclusion and Exclusion Criteria

Participants were the same parents and children who participated in the study described in chapter 4.

5.2.2 Measures

a. ASD screening Measure

1. The Social Responsiveness Scale (SRS; Constantino and Gruber, 2005)

Kindly refer to Chapter 4 for details description of this measure.

2. Weschler Abbreviated Scale of Intelligence – Second Edition (WASI-II), (Weschler, D. 2011)

Kindly refer to chapter 4 for details descriptions of this measure.

b. Experimental Measure

1. The Spence Children's Anxiety Scale-SCAS (Spence, 1998)

Kindly refer to chapter 4 for details descriptions of this measure.

2. Developmental NEuroloPSYcological Assessment –Version II (NEPSY-II; Korkman et al. 2007)

Kindly refer to chapter 4 for details descriptions of this measure.

3. The Short Sensory Profile (Dunn, 1999)

Kindly refer to chapter 4 for details descriptions of this measure.

5.2.3 Procedure

Kindly refer to chapter 4 for details procedure of data collection for this chapter.

5.2.4 Data Analytic Technique

a. Cluster Analysis

Cluster analysis is a mathematical method that can be used to explore which objects in a set are similar (Romesburg, 2004). Objects with similar descriptions are mathematically gathered into the same cluster. The selection of variables for analysis was based on previous literature on anxiety, sensory processing deficits and executive dysfunction theory of autism. Cluster analysis was chosen as the main analysis in this study as this method depends on the estimations of the similarities between pairs of things (*Ibid,* 2004). It is also works as a scientific method called hypothetical-deductive which means, firstly the explanations for the association between EF, SP and anxiety was hypothesized and then deduce in what conditions that this associations is true if the explanation is correct. Therefore, cluster analysis will allow exploration of sub-group membership

through the cluster solutions generated and enable profiling of any indicated group.

b. The use of ClustanGraphics statistical package

Hierarchical cluster analysis was adopted as this method of cluster analysis will show the similarities among objects as a hierarchy. Hence, ClustanGraphics, a statistical package for cluster analysis was used to conduct the analysis (Wishart, 2006). The stages of analysis involved are as follows:

Creation of Excel files suitable for CLUSTAN

Data was firstly entered into SPSS and then converted into Excel files. The Excel framework was developed based on selected variables and level of analysis to suit the research goals. All the missing values were coded with a unique character M. The data was then imported to into the ClustanGraphics and transformed to ensure equal weight for each variable in the analysis. Standardization to Z scores was chosen because the variables are continuous.

From Excel file to the Cluster Analysis results

This is the operational decision stage in utilizing CLUSTAN Graphics. This involves proximity analysis whereby cases are compared in order to evaluate their similarities or dissimilarities. Computing proximities is an intermediate step in the analysis. The Squared Euclidean Distance was used to compute proximities which lead to hierarchical clustering by an increase in the sum of squares, known as Ward's method (Ward, 1963). Hence, Ward's clustering method assigns objects to clusters in such a way that a sum of squares index (*E*) is minimized. The data are presented in 'tree' diagrams (Wishart, 2006).

From Cluster Analysis to Validated Cluster Solution.

This involves validation of the cluster solutions in terms of their within-cluster and between-cluster distances and their outliers (laying outside cluster dataset solutions). In the tree, ClustanGraphics clustered similar cases together into cluster partitions. The cluster partitions are shaded by two colours, yellow and

blue. The yellow colour signifies within cluster grouping and blue colour signifies between cluster groupings of cases for the cluster model. Once the tree is explored, a table of cluster means for each variable and information on cluster membership is displayed. ClustanGraphics can also identify an ‘exemplar’, which is the most typical members of each cluster for a given cluster model. Cluster exemplars are useful in selection of typical cases which are most representative of the cluster.

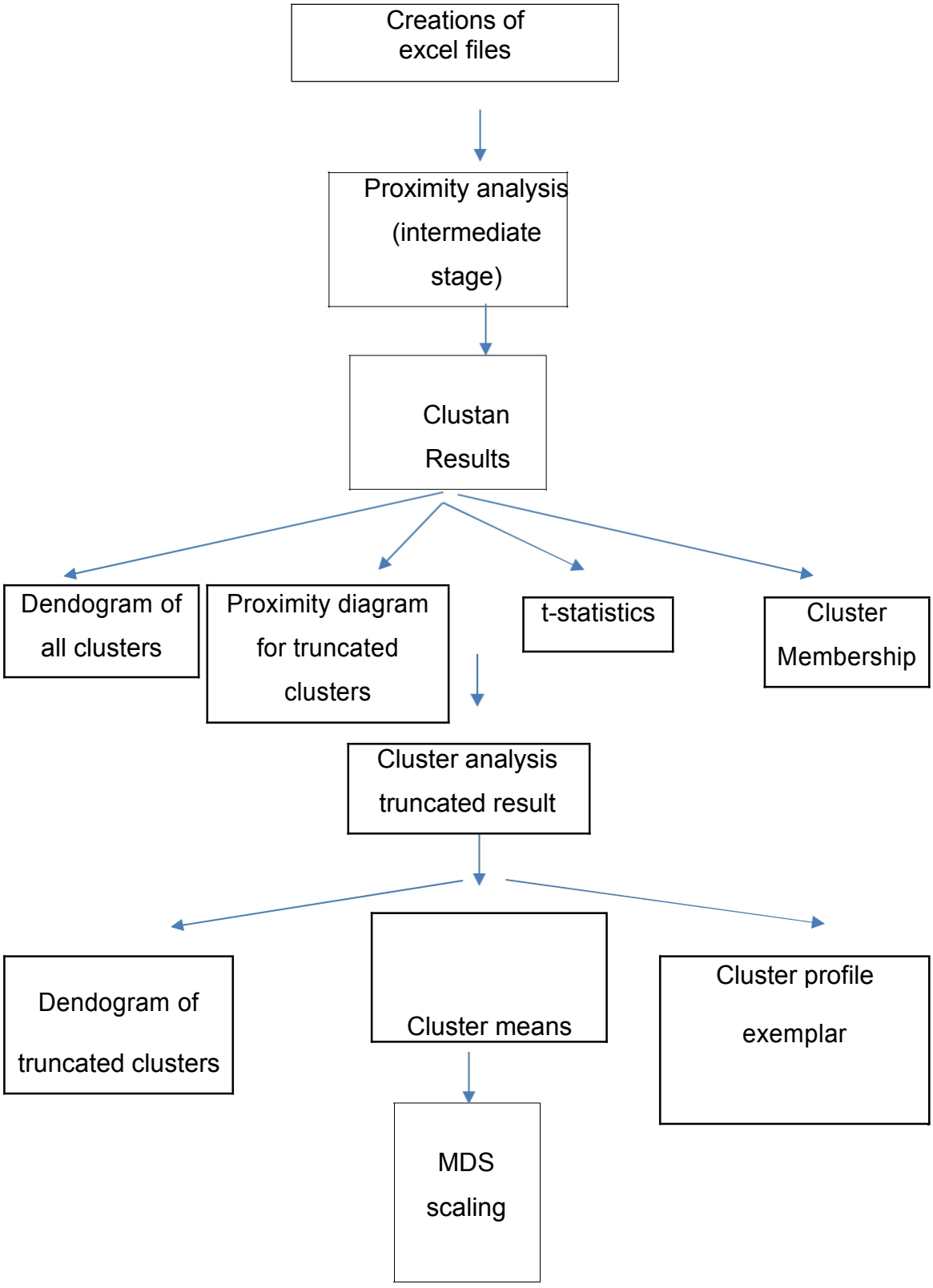
Multidimensional scaling (MDS).

The objective of MDS is to find the structure in a set of proximity measures between the cluster members with underlying hypothesis that the dissimilarities and distances are monotonically related by order (*ibid*). A goodness-of-fit criterion called "stress" measures the extent to which the rank order of the dissimilarities corresponds to the rank order of the distances. The result is a least-squares representation of the objects in that low-dimensional space, which help to further understand the data that was obtained. ClustanGraphics provide this analysis through a computational method called ClustanMDS (*ibid)*. It computes a configuration of points that minimizes the "stress" function in order to obtain a scatter diagram, or plot in which resulted in two or more dimensions which describes the relationships between them and their clusters. In order to run the MDS scaling, the cluster model was highlighted and from the proximity menu the MDS analysis was chosen and then the cluster model will then be displayed on an MDS scatter plot.

The following figure summarizes all the stages involved in cluster analysis:

Figure 5.1

The Stages of Cluster Analysis



5.2.6 Basis for Cluster Analysis in this study

The following factors have been considered in order to form the basis for cluster analysis in this study:

a. Exploring cluster solutions using key variables as predicted by the existing evidence of the potential associations between EF, SP and anxiety in ASD.
b. Based on the cluster solutions that emerged, group membership across variables was explored in order to identify the profiles of any indicated group.

Multiple analyses were run to achieve the aims of study. The level of analysis was as follows:

a. Firstly, cluster analysis was run on the EF variables and anxiety variables to see how these factors clustered together. This means, all the EF and anxiety variables were loaded and the associations were observed. Given that ASD is associated with the presence of both EF deficits and anxiety, a next logical step was to explore whether there are important relationships between these two features (EF and anxiety) and whether EF deficits are associated with a specific anxiety profile in ASD.
b. The next level explored was between SP and anxiety. All the raw scores in the SP subtest were loaded together with parent and children rated anxiety scores. By putting both anxiety and sensory processing simultaneously we can examine whether high or low anxiety is associated with SP and vice versa.
c. Thirdly, EF and SP scores were loaded with anxiety in order to see how they might cluster together. The data obtained helps to reveal some interesting patterns that explain the associations between these two variables, when reciprocal pattern was observed.
d. Finally, age, FSIQ and autism severity were added, firstly by taking each one and loading with EF, then SP and lastly anxiety score. Secondly all were loaded together with each of the variables. At the third level, age, IQ and autism severity were loaded together with all the variables in order to observe the associations.

5.3 Results

5.3.1 Descriptive Results

Descriptive statistics for all the participants (n=36) on all measures can be seen in table 5.1.

Table 5.1

Participant descriptive statistics on all measures

	N=36			
Measures	Mean	SD	Range	**Cronbach's Alpha**
WASI-II	84.67	13.49	64 - 116	
SRS	107.97	30.85	41- 168	.857
NEPSY-II	8.67	2.23	4.25 – 12.50	.824
SCAS-C	56.05	11.71	30-75	.901
SCAS-P	33.00	17.28	1 - 68	.910
SSP	119.81	28.49	64 - 179	.908

Key: **WASI-II** – Wechsler Abbreviated Scale of Intelligence-version II; **SRS** – Social Responsiveness Scale; **NEPSY-II**– Developmental NEuroloPSYcological Assessment –Version II; **SCAS-C** – The Spence Children's Anxiety Scale – Child version; **SCAS-P** – The Spence Children's Anxiety Scale – Parent version; **SSP** – Short Sensory Profile.

5.3.2 Cluster Analysis

Cluster analysis was run at various levels, firstly the main variables of interest EF, SP and parent rated anxiety were explored. Later, in order to determine whether developmental factors may influence the cluster profiles, demographic data (age, severity and IQ) were added. Then the same analyses were run with the child rated anxiety scores.

a. Exploring the influence of EF on anxiety

In this level of analysis, EF was loaded into ClustanGraphics in order to examine the direct relationship with anxiety. The MDS scaling was run also in order to obtain a dendogram which describes the relationships between EF and anxiety. Following the same model as the above, the parent and child rated anxiety scores were loaded in order to compare the consistency of relationship patterns between variables in relation to anxiety.

EF and parent-rated anxiety

In the first analysis, the parent rated anxiety scores were loaded with the EF total score. The best cut procedure showed greatest departure from a random pattern at six cluster models. See figure 5.2. The Mean cluster scores for EF and parent-rated anxiety are as per table 5.2. Figure 5.3 shows MDS scaling which illustrates cluster members in relation to anxiety.

Figure 5.2.
ClustanGraphics dendogram illustrating significant five cluster solutions (cluster analysis 11).

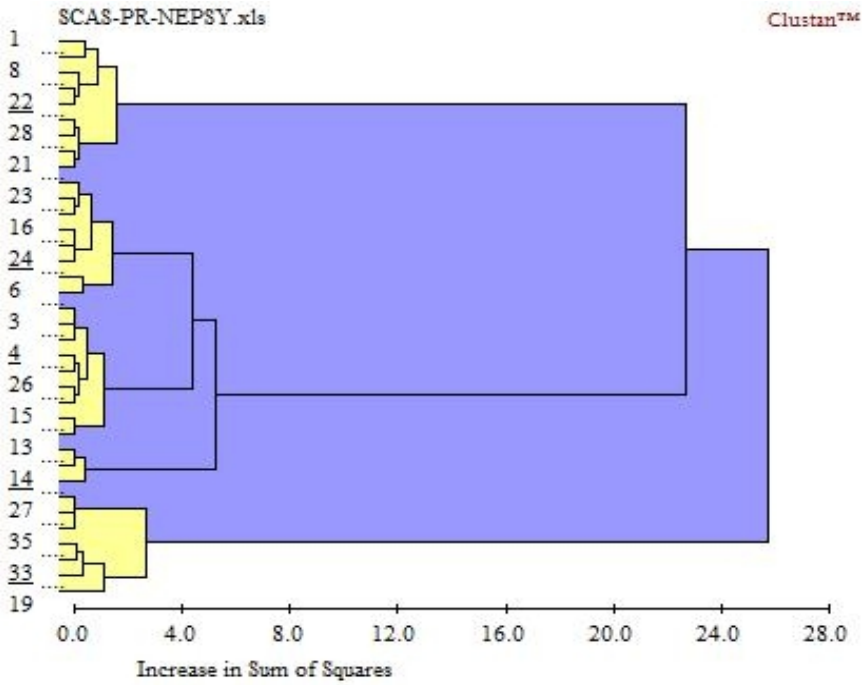


Table 5.2

Mean cluster scores for EF and parent-rated anxiety.

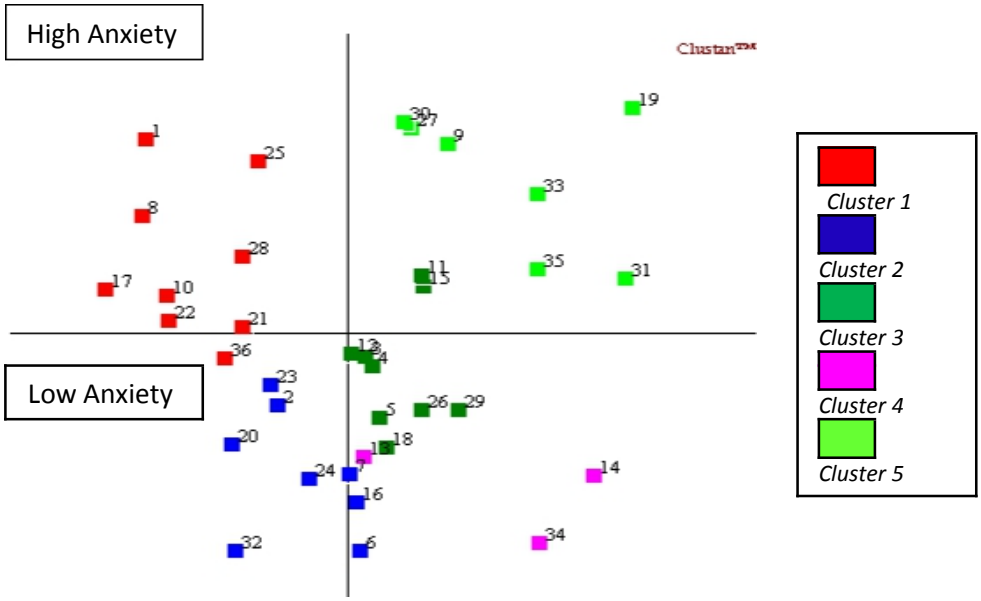
Cluster	N	NEPSY Total score	SCAS-P Total score
1	9	11.37	41.86*
2	8	9.27	14.75
3	9	8.06	29.33
4	3	4.63	18.00
5	7	6.54	56.14*

*Indicative of high anxiety, above mean clinical cut-off

Description of clusters

Figure 5.3

Multi-dimensional scaling illustrates cluster members in relations to anxiety.



Cluster 1: Of the Children in cluster 1 (n=9), seven have mean anxiety score above clinical cut-off. One of them is at borderline and the other one has anxiety score below clinical cut-off. These children have no EF difficulties (within the expected level).

Cluster 2: Cluster 2 consists of nine children. These children demonstrated the lowest mean anxiety score. Their executive functions are within the expected level.

Cluster 3: This cluster represents the same number of children (n=9) with cluster 1. They have mean anxiety scores below clinical cut-off and their EF scores is below expected level

Cluster 4: This cluster has 3 members. This group of children shows low anxiety score and their EF scores are below expected level.

Cluster 5: The seven children in this cluster have the highest anxiety score above clinical cut-off and EF below expected level.

Overall interpretation

There is evidence in one cluster that when anxiety is high, EF is at below expected level (cluster 5). On other clusters it was found that when anxiety scores are within the normal range, EF scores also fall within the normal range (cluster 1 and 2). Other clusters show mixed evidence however as when EF is elevated, it doesn't simultaneously influence high/low of anxiety scores. Therefore, EF dysfunction does not seem to be a consistent contributing factor to anxiety on the parent rated anxiety scores, but may be an important factor for some children.

EF and child-rated anxiety

Total score of parent rated anxiety was then replaced with the child rated anxiety score. Again, the best cut procedure from ClustanGraphics showed greatest departure from a random pattern at six cluster models. See figure 5.4. The Mean cluster scores for EF and child-rated anxiety are as per table 5.3.

Figure 5.4

ClustanGraphics dendogram illustrating significant five cluster solutions (cluster analysis 12).

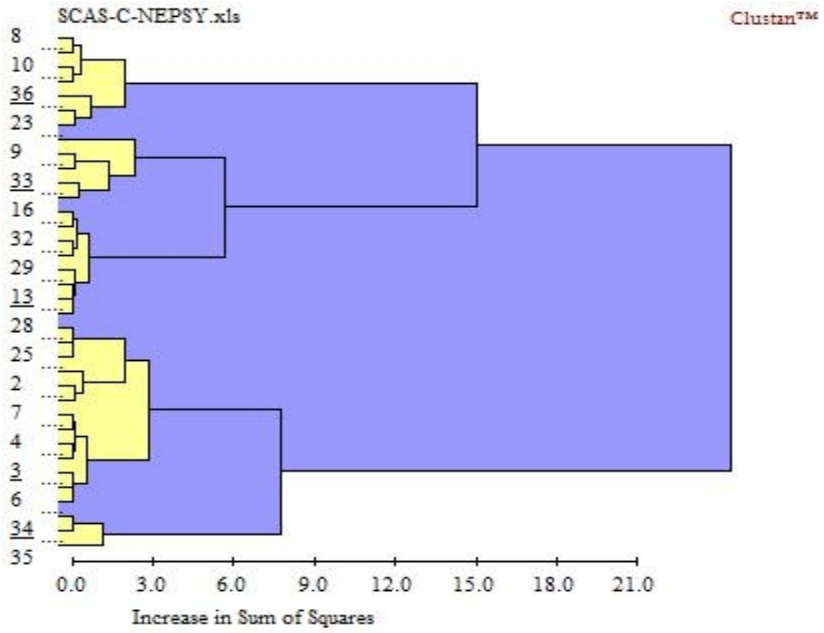


Table 5.3.

Mean cluster scores for EF and child-rated anxiety.

Cluster	N	NEPSY Total score	SCAS-C Total score
1	7	11.41	55.57*
2	5	6.20	57.60*
3	8	8.17	38.50*
4	13	9.16	20.23
5	3	5.25	14.33

**Indicative of anxiety score above clinical cut-off*

Description of clusters

Cluster 1: The seven children in cluster 1 have elevated anxiety scores but EF is at expected level.

Cluster 2: Cluster 2 represents five children who have the highest anxiety scores and their executive functions scores are below expected level.

Cluster 3: This cluster represents eight children who show anxiety score slightly above clinical cut-off mean and their EF scores is below expected level.

Cluster 4: This is the largest cluster (n=13). This group of children also have EF within expected level and low anxiety scores.

Cluster 5: This cluster has three members who have the lowest anxiety score (below clinical cut-off mean). Their EF score is below expected level.

Overall descriptions

For some children, it is evident that when self- rated anxiety is elevated, EF is also impaired. Two of the clusters that have elevated anxiety scores (cluster 2 and 3) have EF scores that indicate impairments (cluster 2) and on cluster 3, they are at borderline level. However, this is not the case for children in other clusters (cluster one) who have the highest anxiety score but EF is at expected level. On other clusters (4 and 5) EF shows no direct influence on high /low anxiety levels which indicates EF is not consistently associated with the heightened anxiety score for all children.

b. Exploring the impact of development and ASD severity on anxiety, in relation to Executive dysfunctions

The impact of development (age and IQ) and ASD severity were examined to explore the relationship with anxiety in relation to EF dysfunctions. In the first instance, the individual variables for development (age and IQ) and also ASD severity were analysed one by one in relation to EF.

In terms of the relationship between age, anxiety and EF difficulties, it was found that there is no consistency in both parent and child reported SCAS cores in

relation to EF and age. When age was replaced by IQ, it was found that IQ does not make a notable contribution to anxiety as rated by children or parents. Instead, IQ does appear to make a contribution to EF difficulties, we find that when IQ is low the EF scores also were predominantly low. ASD severity does not appear to have clear cut relationship with either anxiety or EF difficulties.

c. Relationship of Age, IQ and ASD severity on Parent-rated anxiety, in relation to Executive Dysfunctions

The analysis was repeated by combining the participant's age, IQ and ASD severity in order to see how these affected the cluster solution and the patterns of relationship that would emerge. Therefore, the parent rated anxiety score was loaded together with chronological age (years), full scale IQ score, SRS total score and EF total score. Six cluster solutions were found to be significantly different from random patterns (figure 5.5) and mean cluster scores for all the variables are as per table 5.4.

Figure 5.5

ClustanGraphics dendogram illustrating significant six cluster solutions (cluster analysis 19).

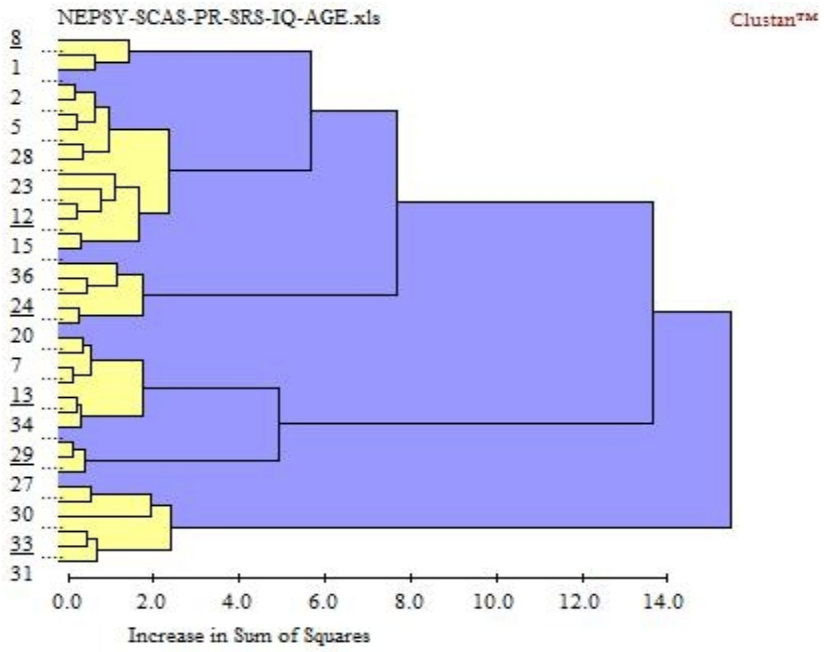


Table 5.4

Mean cluster scores for autism severity, age, IQ, EF and parent-rated anxiety.

Cluster	N	SRS Total score	Age in years	Full scale IQ	NEPSY Total score	SCAS-P Total score
1	3	131.00	10.03	109.00	12.29	51.00*
2	12	127.82	10.31	88.00	9.17	34.91
3	5	64.60	12.84	94.80	9.93	21.60
4	7	96.43	8.05	77.14	7.31**	16.00
5	3	95.50	14.04	65.33	7.31**	22.67
6	6	119.60	14.89	75.83	6.60**	58.00*

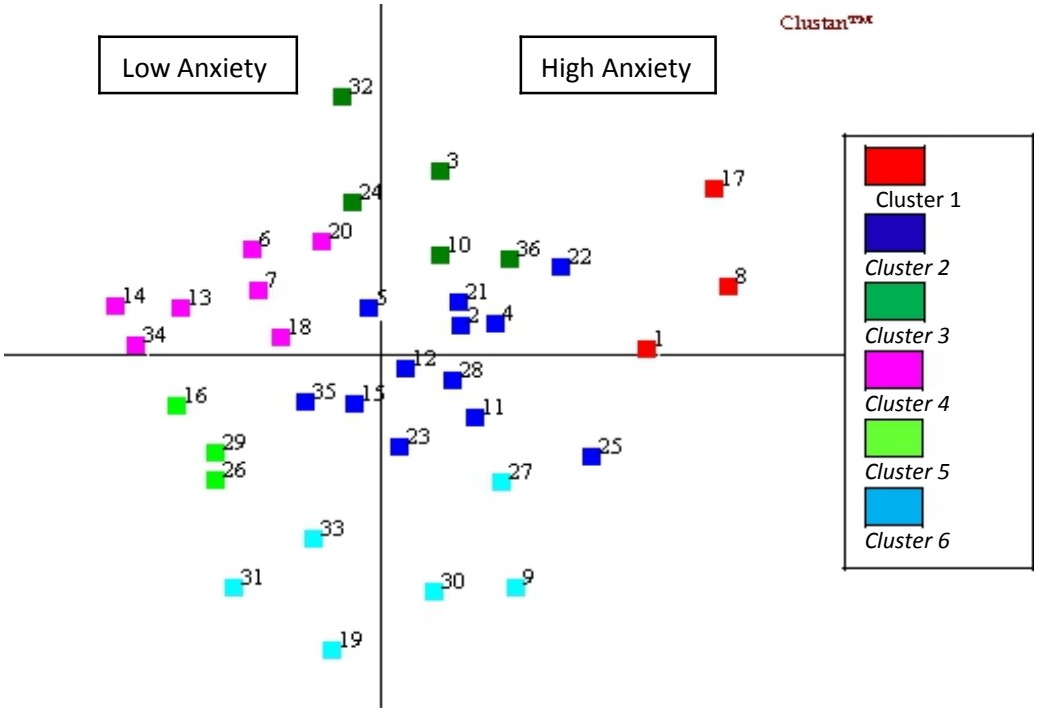
**Indicative of high anxiety/above clinical cut-off mean*

***Indicative of EF difficulties (below expected level)*

Description of clusters

Figure 5.6

ClustanMDS illustrates cluster members in relations to high and low anxiety scores.



Cluster 1: Children in cluster 1 (n=3) have high anxiety levels, EF at expected level, the most severe autism and were slightly younger in age and had average abilities.

Cluster 2: This cluster represents the largest number of children (n=12) anxiety scores are on average above clinical cut-off, EF is at expected level, autism severity scores are high, they are of younger age and low average abilities.

Cluster 3: Cluster 3 represents five children (n=5). These children demonstrated low anxiety scores and EF within expected level. They are from slightly older age range, with mild to moderate autism and average IQ.

Cluster 4: The seven children in cluster 4 have the lowest anxiety scores among all the clusters. Their EF is at borderline level. They are from the youngest age range and they have severe autism and borderline average IQ.

Cluster 5: Children in cluster 5 (n=3) have anxiety within the normal range and borderline EF. They are from the older age range, have severe autism and FSIQ within borderline category.

Cluster 6: this group consists of six children who have the most elevated anxiety scores and EF below the expected level. They are the eldest children with severe autism and borderline FSIQ.

Overall descriptions

In cluster six (n = 6) we see children who are older in age with severe autism and low abilities and high anxiety levels. However, we also see (cluster 1), high anxiety in younger children with average abilities. Therefore, autism severity is the only consistent contributing factor for elevated anxiety in both clusters.

d. Relationship between Age, IQ and ASD severity on child-rated anxiety, in relation to Executive Dysfunctions

In this analysis, we examined child rated anxiety. The score was loaded together with the same variables as above into the ClustanGraphics data files. Six cluster solutions were found to be significantly different from random patterns (figure 5.7) and mean cluster scores for all the variables are as per table 5.5.

Figure 5.7

ClustanGraphics dendogram illustrating significant six cluster solutions (cluster analysis 20).

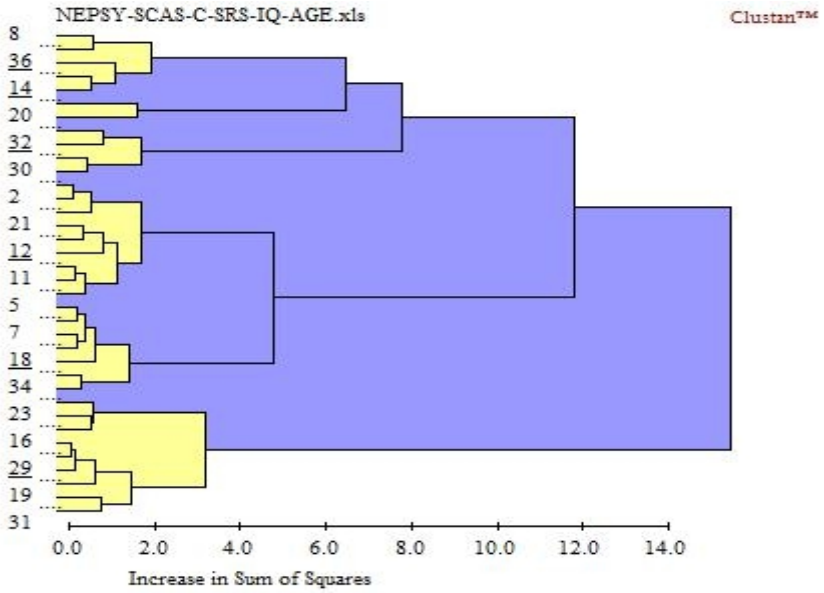


Table 5.5

Mean cluster scores for autism severity, age, IQ, EF and child-rated anxiety.

Cluster	N	Age in years	SRS Total score	Full scale IQ	NEPSY-II Total score	SCAS-C Total score
1	5	11.03	108.25	102.60	11.90	52.00*
2	2	7.53	85.50	81.00	7.31**	76.50*
3	4	13.80	51.00	91.50	8.81	27.25
4	9	10.17	131.88	89.44	9.52	25.67
5	7	8.48	102.14	79.00	7.27**	19.00
6	9	14.39	125.29	72.11	7.00**	45.00*

**Indicative of high anxiety/above clinical cut-off mean*

***Indicative of EF difficulties (below expected level)*

Description of clusters

Cluster 1: Children in cluster 1 (n=5) have anxiety scores above the clinical cut-off, EF at expected level, slightly older age than children in other clusters, severe autism and average abilities.

Cluster 2: Cluster 2 represents children (n=2) who have the highest anxiety scores (well above clinical cut-off mean) and borderline EF. They are the youngest children, with severe autism and their ability is within low average category.

Cluster 3: This cluster represents four children (n=4) who show low anxiety scores, borderline EF, older age, very mild autism and average FSIQ.

Cluster 4: The nine children in this cluster presented with low anxiety levels and EF
at expected level. They are from the slightly younger age group with the most severe autism and low average FSIQ.

Cluster 5: Children in this cluster (n=7) had the lowest anxiety scores below clinical cut-off and borderline EF. They are from a younger age group, with severe autism and borderline FSIQ.

Cluster 6: Children in this cluster (n=9) have anxiety scores above the clinical cut-off, borderline EF, they are the eldest, with severe autism and borderline FSIQ.

Overall description

On the child rated anxiety s, age does not seem to consistently influence anxiety scores. Autism severity also has no apparent relationship with elevated anxiety. Nor does EF difficulties or IQ. There is also no clear evidence in this cluster model that age, IQ and autism severity might fit together with impaired EF.

e. Discussion of the relationships between EF and anxiety

Findings on both the parent and child rated anxiety indicates that older age and ability are not consistently discriminating between clusters. Severity of autism was found to have associations with high anxiety as reported by parents. Interestingly, EF difficulty was found to have more associations with low IQ. When all the developmental variables and autism severity was examined together with EF and anxiety, the findings does not point towards clear associations between these variables.

5.3.4 Exploring the influence of SP on anxiety

In order to explore the potential relationship between anxiety and SP, cluster analysis was undertaken using scores on the child and parent rated SCAS and the parent rated SSP. Firstly, parent rated total score on the SCAS was loaded together with total SSP score. Then, child rated SCAS total score was loaded with SSP. Then the analysis was repeated including ASD severity, IQ and chronological age in order to see how this affected the cluster solution and whether similar results emerged.

SP and parent rated anxiety

The following cluster analysis was run between the score on parent rated SCAS and SSP total score. Five cluster solutions were found to be significantly different from random patterns (figure 5.8) and mean cluster scores for all the variables are as per table 5.6. Figure 5.9 shows MDS scaling which illustrates cluster members in relations to anxiety.

Figure 5.8

ClustanGraphics dendogram illustrating significant three cluster solutions (cluster analysis 21).

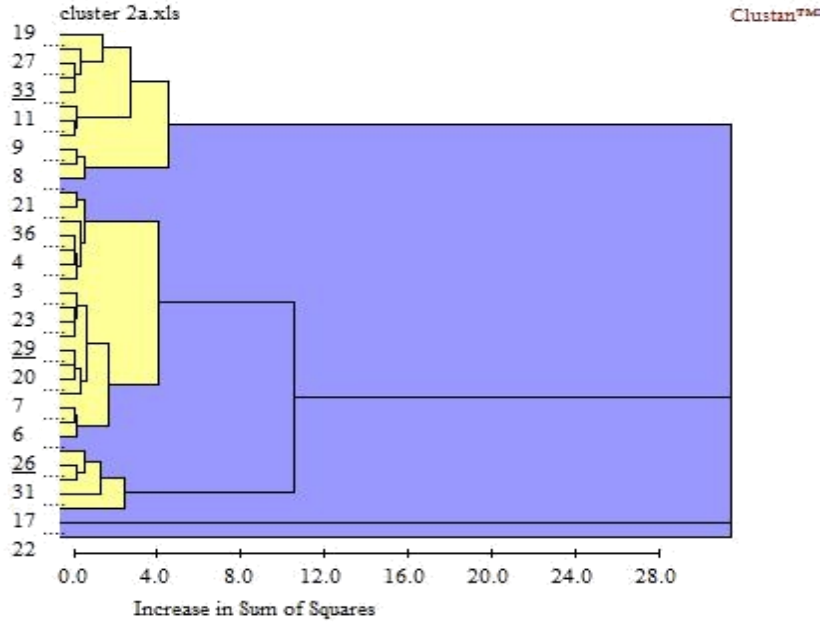


Table 5.6

Mean cluster scores for SP and parent-rated anxiety.

Cluster	N	SSP Total score	SCAS-PR Total score
1	11	22.87**	53.27*
2	18	118.82	22.89
3	5	166.6	24.80
4	1***	0.00	0.00
5	1***	0.00	0.00

***Indicative of high anxiety/above clinical cut-off mean*

***Indicative of SP difficulties (definite difference)*

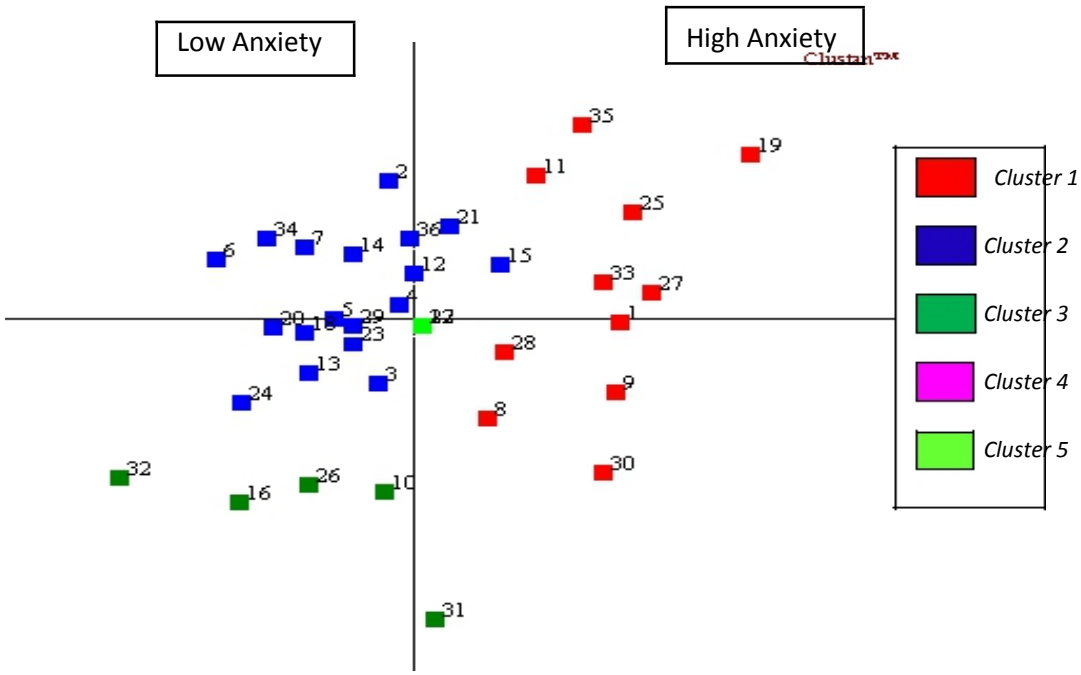
****Only one child made up cluster 4 and 5, therefore represent an outlier within the sample.*

Description of clusters

Figure 5.9

ClustanMDS illustrates cluster members in relations to anxiety.

Participant number 31 and 32 represents outlier within the sample.



Cluster 1: Children in cluster 1 (n=11) has the highest anxiety scores and were most impaired in terms of parent reported sensory processing.

Cluster 2: This cluster represents the largest number of children (n=18) who show low anxiety scores and impaired SP.

Cluster 3: Children in cluster 3 (n=5) have low anxiety scores and SP is at typical performance.

Cluster 4: The child in this cluster (n=1) represents an outlier within the sample. Therefore, meaningful interpretations cannot be made.

Cluster 5: The child in this cluster (n=1) represents an outlier within the sample. Therefore, meaningful interpretations cannot be made.

Overall interpretation

For some children, sensory atypicalities are associated with heightened anxiety (cluster 1), whereas on cluster two, SP is within the definite difference category but anxiety score is low. Therefore SP atypicality alone is not a consistent predominant factor that increase vulnerability to anxiety.

SP and child rated anxiety

The next level of analysis is to investigate how the above variables fit within the children rated anxiety scale (SCAS-C). The best cut procedure showed greatest departure from a random pattern at five cluster models. See figure 5.10. The Mean cluster scores for SP and child-rated anxiety are as per table 5.7.

Figure 5.10

ClustanGraphics dendogram illustrating significant five cluster solutions (cluster analysis 22).

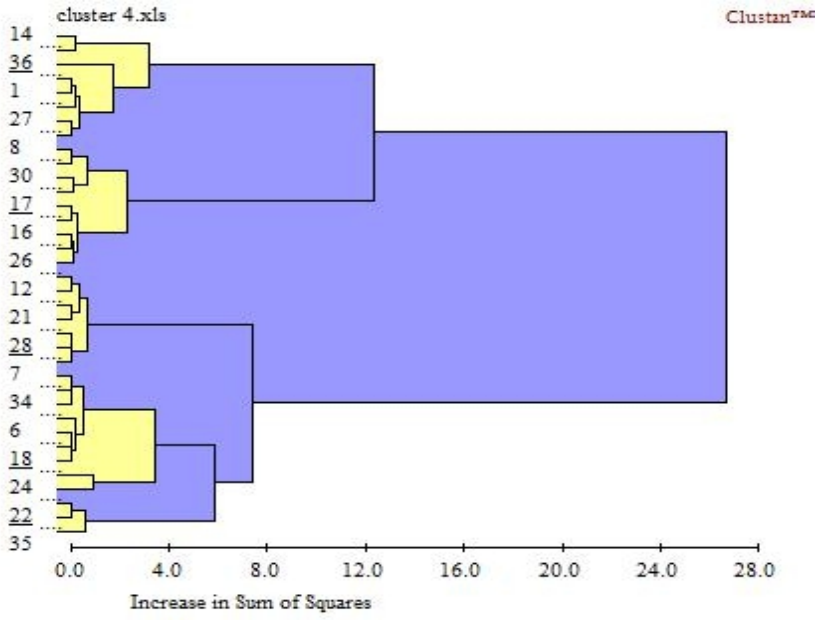


Table 5.7

Mean cluster scores for SP and child-rated anxiety.

Cluster	N	SSP Total score	SCAS-C Total score
1	8	103.88**	59.75*
2	9	148.00	44.00*
3	7	94.40**	32.43
4	9	131.78**	19.00
5	3	80.50**	6.33

**Indicative of high anxiety/above clinical cut-off mean*

***Indicative of SP difficulties (definite difference)*

Description of clusters

Cluster 1: Children in cluster 1 (n=8) have the highest anxiety scores and SP within definite difference category.

Cluster 2: cluster 2 represents nine children who have anxiety scores above clinical cut-off and SP within probable difference category.

Cluster 3: This cluster represents seven children (n=7) who have anxiety scores slightly below clinical cut-off mean. This group of children also has SP within definite difference category.

Cluster 4: This cluster consists of nine children who have low anxiety scores and SP is within definite difference category.

Cluster 5: Children in this cluster (n=3) has the lowest anxiety scores and SP within definite difference category.

Overall interpretation

There is evidence that high anxiety is associated with SP difficulties for some children (cluster 1). However, this is not the case for all children (see cluster 2). Therefore, on the child rated anxiety score, SP atypicality is not associated with heightened anxiety in this group of children.

5.3.5 Exploring the impact of development and ASD severity on anxiety, in relations to SP dysfunctions

Following the above model, the impact of development (age and IQ) and also ASD severity were examined to explore the relationship with anxiety in relations to SP dysfunctions. Result shows that age also was not associated with heightened SP and anxiety. SP was found to make stronger associations with anxiety as compared to age. IQ also is not predominant in influencing either high anxiety or SP difficulties as on low IQ clusters, the SP score is within the normal range. Therefore, it seems that IQ is not a predominant factor in anxiety issues. In terms of autism severity, it was found that autism severity does influence sensory and anxiety issues in ASD. Kindly refer to appendix for result and interpretations of each of the developmental variables and autism severity.

a. The impact of age, IQ and autism severity on anxiety in relations to SP dysfunctions

The next level of analysis is to investigate the characteristics of the variables when they are clustered together with all the demographic variables and autism severity.

Parent rated anxiety

Again five cluster solutions were found to be significantly different from random patterns (figure 5.11) and mean cluster scores for all the variables are as per table 5.8. Figure 5.12 shows MDS scaling which illustrates cluster members in relations to anxiety.

Figure 5.11

ClustanGraphics dendogram illustrating significant five cluster solutions (cluster analysis 29).

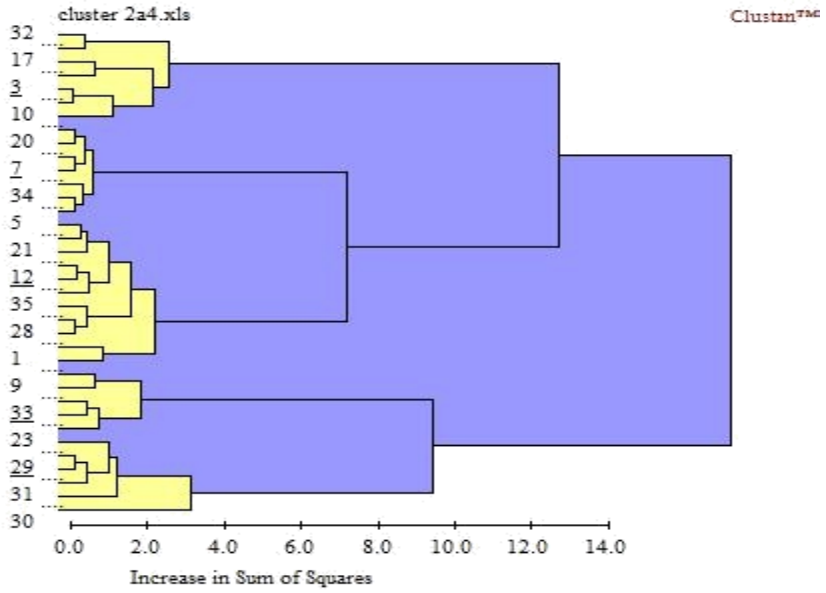


Table 5.8

Mean cluster scores for Age, IQ, autism severity, SP and parent-rated anxiety.

Cluster	N	Age in year	SRS Total score	Full scale IQ	SSP Total score	SCAS-P Total score
1	7	12.47	64.60	98.57	142.40	21.60
2	7	8.05	96.43	77.14	123.00**	16.00
3	11	9.60	123.64	91.73	103.10**	36.91*
4	5	13.66	146.25	78.40	92.40**	59.20*
5	6	14.72	102.40	69.50	153.60	33.33

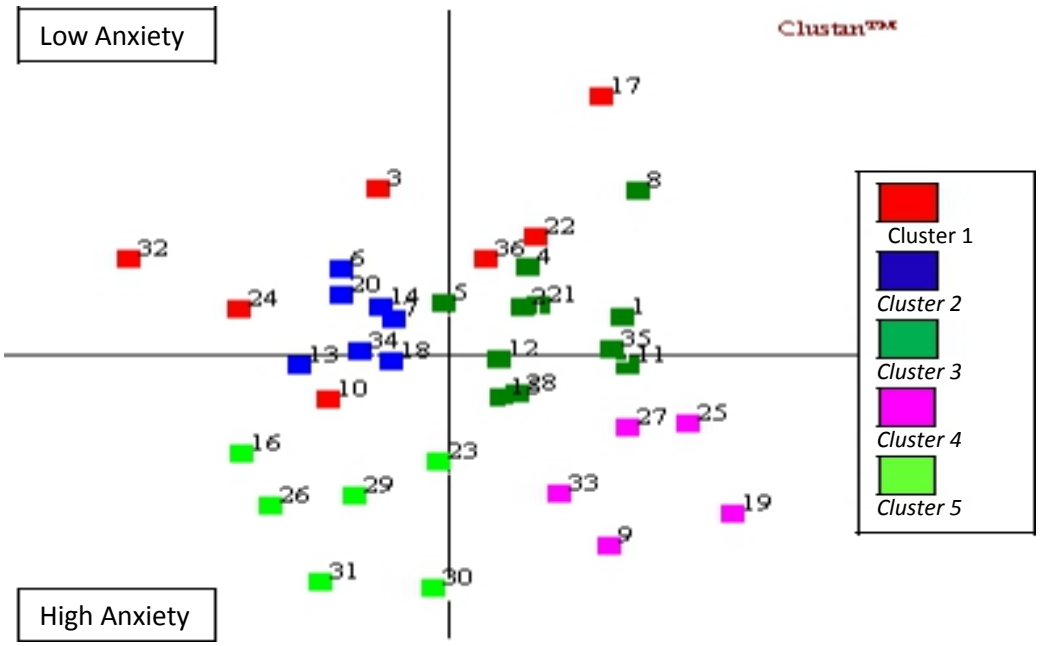
**Indicative of high anxiety/above clinical cut-off mean*

***Indicative of SP difficulties (definite difference)*

Figure 5.12

ClustanMDS illustrates cluster members in relations to anxiety.

Cluster descriptions



Cluster 1: Children in cluster 1 (n=7) have the low anxiety scores, probable difference in terms of sensory processing, are older with mild to moderate autism and average FSIQ.

Cluster 2: cluster 2 represents seven children who demonstrate the lowest anxiety scores, SP within the probable difference category, the youngest age range, severe autism and borderline FSIQ.

Cluster 3: This cluster represents the largest number of children (n=11) who show heightened anxiety scores, SP within definite difference category, younger age group, severe autism and average FSIQ.

Cluster 4: Cluster 4 (n=5) has the highest anxiety scores above clinical cut-off, SP scores within the definite difference category, older age group, the most severe autism and FSIQ within borderline category.

Cluster 5: Cluster 5 has anxiety scores slightly below clinical cut off, the fewest sensory issues (within typical performance group) and are the eldest group. They have severe autism and lowest FSIQ (extremely low category).

Overall interpretations

The above profile shows that cluster 3 and 4 (n = 16) have high anxiety scores (above clinical cut-off mean) and they are also characterized by sensory difficulties. This group of children also have high ASD severity. However, age and ability are not consistently associated with their vulnerability to SP difficulties and anxiety problems. On cluster three, the children have average ability and are from younger age range even though they have SP difficulties and high anxiety. This indicates high anxiety is particularly associated with SP difficulties and high ASD severity.

Child rated anxiety

As for the parent rated anxiety, this analysis aimed to investigate the characteristics of the variables when they are clustered together with the demographic variables and autism severity. The same variables were retained except the parent rated anxiety score was replaced by child rated anxiety score. The total score of child rated anxiety, SSP, SRS, chronological age (years) and Full scale IQ were subjected to ClustanGraphics. Again five cluster solutions were found to be significantly different from random patterns (figure 5.13) and mean cluster scores for all the variables are as per table 5.9.

Figure 5.13

ClustanGraphics dendogram illustrating significant five cluster solutions (cluster analysis 30).

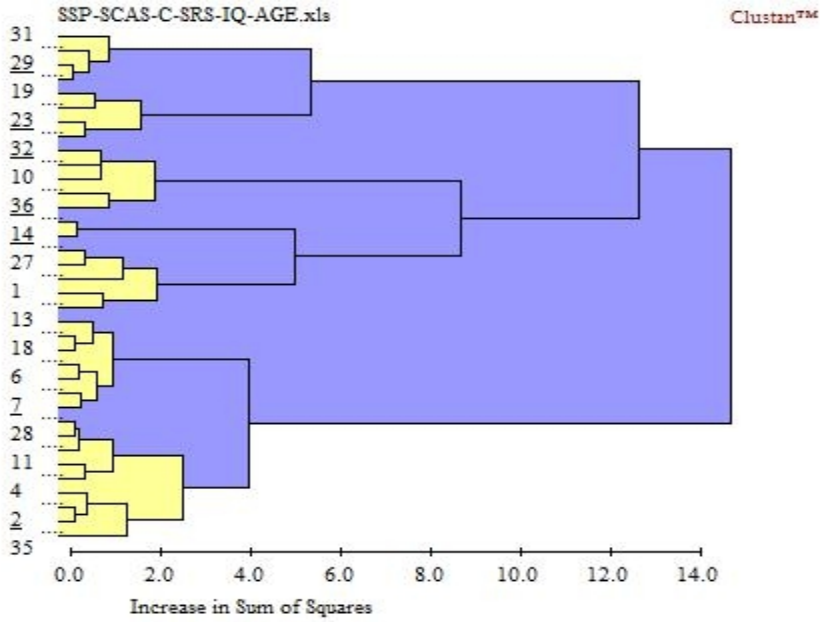


Table 5.9

Mean cluster scores for Age, IQ, autism severity, SP and child-rated anxiety.

Cluster	N	SRS	Age in years	Full scale IQ	SSP Total Score	SCAS-C Total score
1	4	106.67	14.55	65.75	169.00	35.25*
2	4	147.00	14.32	73.75	102.00**	53.25*
3	5	56.20	13.45	90.20	148.40	31.00
4	2	85.50	7.53	81.00	121.50**	76.50*
5	5	118.00	11.44	103.80	110.00**	53.00*
6	7	104.29	8.20	79.86	120.29**	23.00
7	9	130.00	10.38	88.78	93.14**	22.56

**Indicative of high anxiety/above clinical cut-off mean*

***Indicative of SP difficulties (definite difference)*

Description of clusters

Cluster 1: Children in cluster 1 (n=4) have anxiety scores slightly above clinical cut off, they are the most able group in terms of SP abilities (typical performance), have severe autism, are the eldest group and have low FSIQ.

Cluster 2: Cluster 2 represents those children (n=4) who demonstrated high anxiety, impaired SSP, the most severe autism, they were an older age group and had borderline FSIQ.

Cluster 3: This cluster represents five children who show anxiety scores slightly below the clinical cut-off, SP within probable difference category, very mild autism, an older age range and borderline FSIQ.

Cluster 4: Children in this cluster have the highest anxiety score, SP atypicalities within definite difference category, have severe autism, and they are the youngest who have low average FSIQ.

Cluster 5: Children in this cluster (n=5) have high anxiety scores, SP within definite difference category, severe autism, they are slightly older age group and with average FSIQ.

Cluster 6: The seven children in this cluster have the low anxiety scores, SP within definite difference category, severe autism, a younger age range and borderline FSIQ.

Cluster 7: This cluster consists of nine members. They have the lowest anxiety score, SP within definite difference category, severe autism, slightly younger age group and low average FSIQ.

Overall descriptions

On the child rated anxiety, children on cluster 2, 4 and 5 (n=15) are children that have heightened anxiety scores (above clinical cut-off) and they are also characterized by SP difficulties. However, children on cluster 1 (n=4) have anxiety scores slightly above clinical cut-off mean but their SP scores falls within typical performance. Further examination on their scores on their profile, it was found that they have the lowest abilities and are the eldest age group. All clusters that have high anxiety scores, also have high ASD severity. Age and IQ are not consistent contributing factors as on clusters that have heightened anxiety only cluster 1, 2 and 5 represent the older age range whereas members of cluster 4, who have the highest anxiety score, are the youngest children. IQ also was found to have no consistent influence on the heightened anxiety scores as children on cluster 4 and 5 have average abilities whereas children in cluster 1 and 2 have low abilities.

5.3.6 Discussion on relationship between SP and anxiety

SP atypicalities was examined together with anxiety and the result shows that for some children SP atypicality is not associated with heightened anxiety on both the parent and child rated anxiety score. When SP and anxiety are combined together with age, IQ and autism severity the result shows that age and abilities are not consistently associated with vulnerability to SP difficulties and anxiety problems in this group of children. Further examination on all clusters that have high anxiety scores shows they are also have high ASD severity ratings. This findings is consistent across parent and child anxiety reports. This indicates that for some children, high anxiety is associated with SP difficulties and high ASD severity.

5.3.7 Exploring subgroups of children according to their performance on anxiety in relations to EF and SP dysfunctions

a. Relationship between parent-rated anxiety, Executive and Sensory processing dysfunctions

To explore this potential relationship at sub-group level, cluster analysis was undertaken using scores on SCAS-P total score, NEPSY combined score and SSP total score as key variables. The 'best cut' procedure in ClustanGraphics indicated that the greatest departure from a random pattern occurred at five cluster model (see figure 5.14). Mean cluster scores for each measure are shown in table 5.10.

Figure 5.14

ClustanGraphics dendogram illustrating significant five cluster solution (cluster analysis 1)

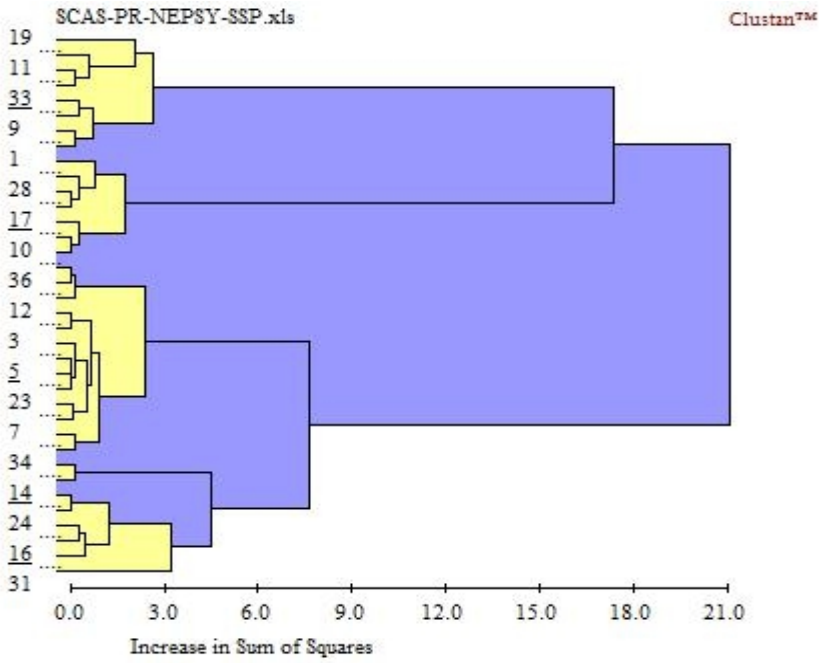


Table 5.10.

Mean cluster scores for parent-rated anxiety and measures of EF and SP

Cluster	N	NEPSY total score	SSP total score	SCAS-P total score
1	8	7.11***	95.13**	53.50*
2	7	11.57	119.25**	46.60*
3	13	9.16	118.69**	23.00
4	2	4.63***	114.00**	16.50
5	6	7.53***	165.00	21.50

**Indicative of high anxiety/above clinical cut-off mean*

***Indicative of SP difficulties (definite difference)*

****Indicative of EF difficulties*

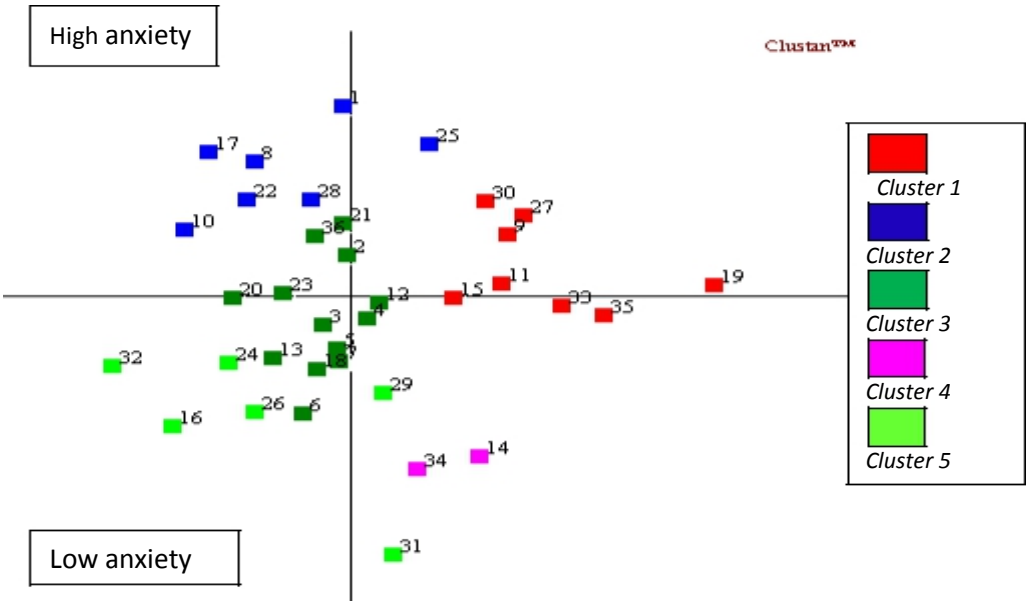
Description of clusters

Clusters are illustrated in figure 5.15 with regard to executive function, sensory processing and anxiety scores.

A hierarchical cluster analysis by Ward's Method was then mapped on to the final 2-dimensional MDS configuration. This is an ordination of 36 cluster members according to the composition of their anxiety, colour coded by the 5-cluster model:

Figure 5.15

Multi-dimensional scaling illustrates cluster members in relations to anxiety.



Cluster 1: Children in cluster 1 (n=8) have the highest anxiety scores. They are the group that is the most impaired in terms of sensory processing. Their executive functions are at borderline level.

Cluster 2: Cluster 2 represents those children (n=7) who have the next highest anxiety scores, lower levels of sensory difficulties though the mean remains within the definite difference range. Their Executive functions are at expected level.

Cluster 3: This cluster represents the largest number of children (n=13) who demonstrate anxiety below indicative clinical cut-off though only marginally. In terms of sensory processing atypicalities, they are within the probably difference range. Their executive functions are at expected level.

Cluster 4: The two children in this cluster have the lowest anxiety score. They are the most impaired group in terms of executive function (below expected level). However, this group has no evidence sensory processing difficulties.

Cluster 5: The six children in cluster 5 have anxiety below the indicated clinical cut-off. Their sensory processing however is impaired (definite difference category). They demonstrate borderline level of executive functions.

Overall Descriptions

For some children, there appears to be an association between high SP and poor EF with heightened anxiety (cluster 1). However, further examination of other clusters shows that children in cluster 2 (n=7) who have the next highest anxiety scores and SP difficulties, however their EF scores is at expected level. Therefore, it appears that heightened anxiety scores are associated with sensory atypicalities and not the EF difficulties. On other clusters, it appears that there is no clear relationship between EF and anxiety as EF scores are varied, for instance on cluster one, EF is at borderline level when anxiety is high but for some children poor EF is not associated with heightened anxiety or SP difficulties (cluster 4). Further examination on the relationship between SP, EF and anxiety indicates that SP has a stronger association with EF difficulties rather than anxiety in this group of children (cluster 5).

b. Relationship between child-rated anxiety, Executive and Sensory processing dysfunctions

The next level of analysis involves the same variables but with child rated anxiety scores. The total scores of NEPSY, SSP and SCAS-C were loaded to ClustanGraphics. Again, the greatest departure from a random pattern occurred at the five cluster solutions (figure 5.16). Cluster means can be seen in table 5.11.

Figure 5.16

ClustanGraphics dendogram illustrating significant five cluster solutions (cluster analysis 2).

Table 5.11

Mean cluster scores for EF, SP and child-rated anxiety.

Cluster	N	NEPSY total score	SSP total score	SCAS-C total score
1	7	11.41	126.00**	55.57*
2	5	6.20**	98.20**	57.60*
3	7	7.40**	157.83	36.71*
	5	10.54	91.67**	21.00
5	12	7.84**	113.75**	21.00

**Indicative of high anxiety/above clinical cut-off mean*

***Indicative of SP difficulties (definite difference)*

****Indicative of EF difficulties (below expected level)*

Description of clusters

Cluster 1: Seven children formed cluster 1. They demonstrate high anxiety, have SP within definite difference category and their EF is at expected level.

Cluster 2: Cluster 2 represents five children. Children in this cluster had a high anxiety scores. Their executive functions are at expected level. In contrast, they demonstrated impaired sensory processing (definite difference level).

Cluster 3: The seven children in cluster 3 shows anxiety above the indicative clinical cut off but markedly lower than clusters 1 and 2. Their EF is at borderline level and they are typical in terms of sensory processing.

Cluster 4: Children in cluster 4 (n=5) demonstrated anxiety below the indicative clinical cut off. They also demonstrate expected level of EF. However, they are the most impaired group among all the clusters in terms of sensory processing. Their SP score falls within definite difference category.

Cluster 5: Cluster 5 consist the highest number of children (n=12). They are the group that has the same low anxiety score as cluster 4. They demonstrated borderline EF but impaired SP (definite difference category).

Overall descriptions

On the child rated anxiety score, when EF, SP and anxiety was combined, it appears that for some children, poor EF and high SP are characterizing the heightened anxiety scores in this subgroups of children (cluster 2). Between EF difficulties and SP atypicalities, SP was found to make a stronger association with anxiety (cluster 1 and 2). Low EF was found to have relationship with SP difficulties and heightened anxiety in cluster 2. However, this is not the case for cluster one as children in this cluster have impaired SP and heightened anxiety scores, but their EF scores are at expected level. Further examination of other clusters indicates that SP is not consistently associated with either heightened anxiety or impaired EF as children on cluster 4 and 5, their anxiety score is low and their EF cores are varies in high/low. Therefore, on the child rated anxiety, when EF, SP and anxiety were combined it appears that the relationship becomes less clear.

c. Exploring the Impact of development and severity on anxiety, in relations to EF and SP dysfunctions

To explore the potential impact of developmental factors and ASD severity on anxiety, chronological age (months), full scale IQ and SRS total score were added as extra variables to the above cluster analysis. The analysis with each of them (age, IQ and severity) was run separately first before finally all the developmental factor, severity and other variables were loaded and analyzed altogether. In each level of analysis, the parent and child rated anxiety were compared in order to understand anxiety manifestations more thoroughly.

When considering the interaction with age, on the parent rated anxiety score, there is evidence that for the older group of children with EF and SP difficulties there is high anxiety. There is consistent evidence also that older age and EF difficulties tend to cluster together. On child rated anxiety scores, when age was added, it was observed that there are mixed evidence as to whether age is consistently associated with anxiety, EF and SP dysfunctions. On the parent and child rated anxiety, when IQ was added, there is inconsistent evidence that IQ contributes to anxiety difficulties as well as EF and SP impairment. It was observed also that for most of the clusters that have the SP impairment, FSIQ are at borderline, low average and extremely low average category. It appears that SP contributes the most to the high anxiety scores. However, IQ has no consistent moderating effect on anxiety. When autism severity is also considered high ASD severity does not influence the patterns of association in the variables.

On the child rated anxiety, it appears that sensory impairment and autism severity may be risk factors for elevated anxiety in some children with ASD. A child who has sensory difficulties, high autism severity and low executive function, appear to be particularly at risk for anxiety regardless of IQ or age. Kindly refer to **Appendix H** for individual results and interpretations of each of the developmental variables and autism severity. The combined analysis is presented here.

d. The impact of age, IQ and autism severity on parent and child rated anxiety, in relations to EF and SP dysfunctions

Developmental and autism severity variables were analyzed with parent rated anxiety, EF and SP variables. The objective of this analysis is to examine the impact of development and severity on anxiety, in relations to EF and SP dysfunctions.

Parent rated anxiety

Chronological age (in months), full scale IQ and total score of SRS were added into ClustanGraphics together with the parent rated SCAS, NEPSY total score and SSP total score. The best cut procedure from showed greatest departure from a random pattern at six cluster models. See figure 5.17. The Mean cluster scores for age, IQ, autism severity, EF, SP and parent-rated anxiety are as per table 5.12.

Figure 5.17

ClustanGraphics dendogram illustrating significant six cluster solutions (cluster analysis 9).

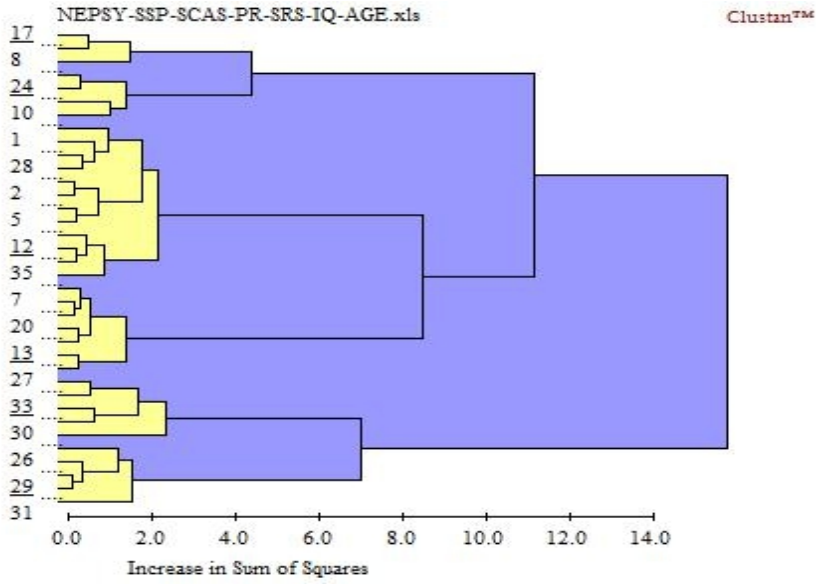


Table 5.12.

Mean cluster scores for age, IQ, autism severity, EF, SP and parent-rated anxiety.

Cluster	N	Age in years	SRS Total score	Full scale IQ	NEPSY Total score	SSP Total score	SCAS-P total score
1	3	11.35	115.50	111.00	11.71	118.50**	36.50*
2	4	12.81	57.25	93.25	9.72	152.00	20.00
3	12	9.89	126.45	89.58	9.38	98.10**	37.82*
4	7	8.05	96.43	77.14	7.31***	123.00**	16.00
5	5	14.66	117.25	77.60	7.00***	102.60**	60.40*
6	5	14.46	115.00	67.80	7.31***	158.50	27.80

**Indicative of high anxiety/above clinical cut-off mean*

***Indicative of SP difficulties (definite difference)*

****Indicative of EF difficulties (below expected level)*

Description of clusters

Cluster 1: Children in cluster 1 (n=3) had elevated anxiety scores, were impaired in terms of sensory processing. Executive functioning was within expected level. They are from the older group of children with severe autism. Their full scale IQ falls within high average category.

Cluster 2: Cluster 2 represents four children. These children demonstrated normal range of anxiety, executive function at expected level and had SP within typical performance. They are from older age group and in contrast with cluster 1, they present with less severe autism. Their FSIQ is within the average category.

Cluster 3: This cluster represents the largest number of children (n=12) who show elevated anxiety scores, EF within expected level and SP within probable difference category. They are from younger age group and severe autism. Their FSIQ is within the low average category.

Cluster 4: The seven children in cluster 4 have the lowest anxiety scores and are the most impaired group in terms of executive function. Their SP is also impaired.

These children are the youngest among all the cluster members who presents with severe autism. Their FSIQ falls within the borderline category.

Cluster 5: Children in cluster 5 (n=5) have the most elevated anxiety scores across all the clusters. They are also demonstrate the lowest score in terms of EF (borderline) and SP within definite difference category. They are the oldest children in all the clusters and presented with severe autism. They have borderline FSIQ.

Cluster 6: This cluster (n=5) have low anxiety scores, EF within borderline category and SP in definite difference category. Their autistic symptoms are within the severe range and they are in the older age group of children. These children have the lowest FSIQ across all the clusters.

Overall description

Cluster 1, 3 and 5 have elevated anxiety scores and high ASD severity. It is inconsistent as to whether age is a contributing factor to anxiety as cluster 3 represents younger children and yet they have high anxiety. Children in cluster 8 are older members but have low anxiety scores. In terms of IQ, it was found that in those clusters with heightened anxiety scores, also have higher IQ (cluster 1, 3 and 5). On cluster four, the children have higher IQ but low anxiety whereas on cluster six, the cluster members have low IQ and low anxiety. High ASD severity was also associated with high anxiety (cluster 1, 3 and 5). However, children in cluster 4 and 6, have low anxiety scores even when their ASD severity is high. It seems that heightened anxiety in this subgroup of children are associated with SP difficulties and characterized also with higher ability and high ASD severity.

Child rated anxiety

In this analysis, the child rated anxiety score replaced the parent rated anxiety score. All the other variables were retained. The best cut procedure in

ClustanGraphics indicated that the greatest departure from a random pattern occurred at the seven cluster model (see figure 5.18). Mean cluster scores for each measure are shown in table 5.13.

Figure 5.18

ClustanGraphics dendogram illustrating significant seven cluster solutions (cluster analysis 10).

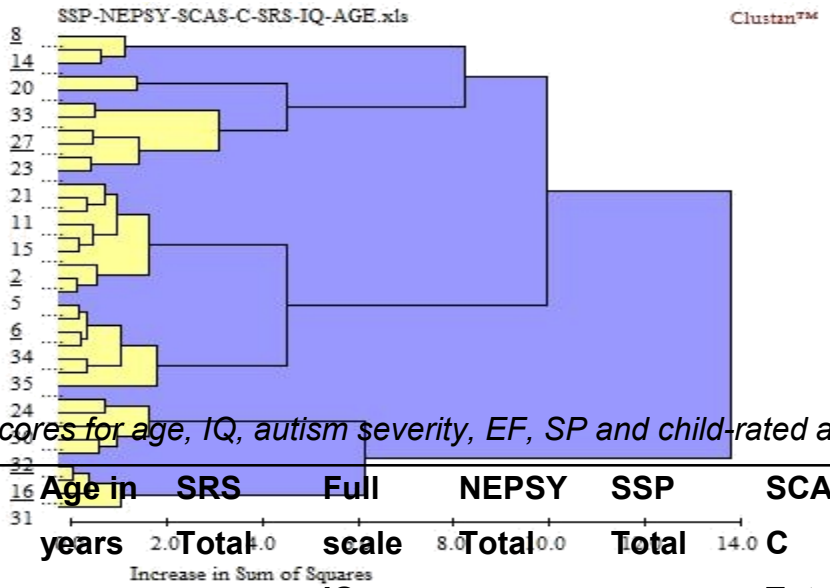


Table 5.13

Mean cluster scores for age, IQ, autism severity, EF, SP and child-rated anxiety.

Cluster	N	Age in years	SRS Total score	Full scale IQ	NEPSY Total score	SSP Total score	SCAS-C Total score
1	3	10.03	131.00	109.00	12.29	119.00**	51.33*
2	2	7.53	85.50	81.00	7.31***	121.00**	76.50*
3	6	14.06	130.20	81.17	7.92***	101.67**	54.00*
4	6	10.17	131.88	89.44	9.52	97.57**	25.67
5	7	8.48	102.14	79.00	7.27***	115.86**	19.00
6	5	13.45	56.20	90.20	9.43	148.40	31.00
7	4	14.55	106.67	65.75	6.42***	169.00	35.25*

**Indicative of high anxiety/above clinical cut-off mean*

***Indicative of SP difficulties (definite difference)*

****Indicative of EF difficulties (below expected level)*

Description of clusters

Cluster 1: This cluster consists of three children. They have anxiety scores above the clinical cut-off and impaired SP. However, EF scores are within the expected level. They are among the most severe group of children in terms of

ASD severity and their FSIQ falls within average category. They are from the older group of children.

Cluster 2: Cluster 2 represents 2 members. These children have the highest anxiety scores. They demonstrate borderline levels of executive function and impaired sensory processing. They are the youngest among all the other cluster members, presented with severe autism and FSIQ falls within the low average category.

Cluster 3: This cluster represents the six children who show anxiety scores above the clinical cut-off, borderline EF and impaired SP. They are among older age group, severe autism and FSIQ within the low average category.

Cluster 4: The six children in this cluster have low anxiety scores, EF at expected level and impaired SP. They represent and older group of children with severe autism and FSIQ within low average category.

Cluster 5: Children in this cluster (n=7) represent the largest cluster and have anxiety below the clinical cut-off, borderline EF and impaired SP. They are from younger age group with severe autism and borderline FSIQ.

Cluster 6: Children (n=5) in this cluster have anxiety below clinical cut-off, EF is at expected level but SP is within the probable difference category. They are from the older age group, severe autism and average FSIQ.

Cluster 7: This cluster represent four children who demonstrated high score, impaired EF and SP. They are the eldest children among all the clusters with severe autism and the lowest FSIQ score (extremely low category).

Overall description

It seems that impaired SP, older age and severity of autism are associated with anxiety in clusters 1, 3 and 7. However, this is not the case for children in cluster 2 as they have the highest anxiety scores and yet they are the youngest. In terms

of IQ, children in cluster 1, 2 and 4 who have high anxiety scores, are also characterized with high ability. This indicates that anxiety issues are common in high functioning children with ASD. Children in all the clusters with heightened anxiety scores, are also characterized with high ASD severity. Therefore, it appears to be a clear pattern that heightened anxiety are frequently associated with SP atypicalities and high ASD severity.

5.4 Discussion

5.4.1 Overview

The primary aim of this study was to determine whether subgroups of children can be identified within an ASD sample based on their profiles in relation to anxiety, executive functioning and sensory atypicalities, whilst taking into account other developmental characteristics such as age, ability and ASD severity. Various steps or levels of cluster analyses were undertaken to enable the heterogeneity of ASD to be taken into account.

5.4.2 Heterogeneity of the sample

Maximum variation sampling, also known as heterogeneous sampling was used to capture a wide range of perspectives relating to EF, SP and anxiety in children with ASD. This method of sampling helps to gain greater insights into variations in EF, SP and anxiety phenomena. . Hence, heterogeneity of sampling adopted allows the profiling of EF and SP and anxiety in this subgroup of children. A broad and diverse range of participants in terms of age range and autism severity also allows proportionate representation of the influence of these variables on the constructs being studied (EF, SP and anxiety).

5.4.3 Subgroups of children with ASD on anxiety, according to their performance on EF

Results indicated that EF dysfunctions are not a consistent contributing factor to anxiety in ASD according to both parent and child rated anxiety. This does not

support previous research which suggested that there may be an association between reduced performance on tasks of executive functioning, attentional switching and verbal working memory and the presence of greater levels of anxiety (Gunther et al.,2013; Toren et al. 2000, Hollocks et al. 2013). Our findings however, do not indicates a clear universal pattern of associations between executive functioning difficulties and anxiety problems in this subgroup of children with ASD.

5.4.3 Subgroups of children based on performance of SP and anxiety

There is some indication that sensory atypicalities are associated with anxiety for some children. However, this is not the case for all children. This suggests that SP difficulties are not always related to high anxiety in a consistent way. Some children who have high anxiety levels may have higher level of SP atypicalities whilst some show relatively low levels of impairment. The impact of development (age and IQ) and also ASD severity were examined to explore the relationship with anxiety in relations to SP dysfunctions. Results shows that age and ability are not consistently associated with vulnerability to SP difficulties and anxiety problems. The results further suggest that for some children high anxiety is associated with SP difficulties and the presence of higher levels of ASD severity.

Our findings support some previous work indicating that unusual aversion to common sensory stimuli may cause anxiety (White et al, 2009 & Bellini, 2006, Ben-Sasson et al., 2009; Liss et al., 2006; Pfeiffer et al., 2005). The result of the cluster analyses suggests that subgroups of children with heightened anxiety and SP difficulties can be identified. The profile of these children is further characterized by high ASD severity. These findings support the above studies and also the primary anxiety model as proposed by Green and Ben-Sasson

(2010). Our findings also indicate that higher levels of ASD severity contribute to heightened anxiety problems which parallels findings by Howlin, (1998) and Thomas et al (1998), perhaps reflecting that stereotyped behaviour and other complex behaviours are self-calming strategies and these behaviours play key roles in keeping fear and anxiety under control (Howlin, 1997).

Of course it is possible that SOR and anxiety are unrelated, but appear to be correlated due to diagnostic overlap. The two conditions can be difficult to distinguish, as they both involve misperception of threat (e.g., Schoen et al. 2008) and overlap in their physiological (e.g., increased heart rate and skin conductance response) and behavioural (e.g., fight-or-flight response, emotional dysregulation, avoidance) symptoms. Investigators need to be particularly careful in how they identify each condition (SP abnormalities and anxiety). Ben-Sasson et al. (2007) found that there is an overlap in judgments of sensory over-responsivity and anxiety between occupational therapists and psychologists. This supports the notion that these constructs in part reflect different professionals' perspectives upon behaviours. There is need for more studies that integrate paradigms from occupational therapy and psychology to create more consistent diagnoses between the two fields.

5.4.3 Subgroups of children based on performance of EF, SP and anxiety

Cluster analysis results based on EF, SP and parent reported anxiety scores identified fifteen children with high anxiety who made up two clusters. Children in these clusters had parent reported high SP atypicalities indicating that anxiety issue is associated with sensory abnormalities in these subgroups of children. However, interestingly In terms of the relationship between EF and anxiety, it was found that there is less clear pattern with EF scores varying on these clusters. Further examination on other clusters found that sensory atypicalities is making a stronger contribution to anxiety problems than EF. When all these constructs were combined (EF, SP and anxiety) it was found that high/low EF difficulties are better predicted by SP atypicalities rather than the heightened anxiety scores.

Previous studies suggest that SOR is a predictor of anxiety in children with ASD (Ben-Sasson et al., 2009; Liss et al., 2006; Pfeiffer et al., 2005). In our exploratory study, based on the profile of the subgroups that emerged, we

managed to identify that SP difficulties are predominantly associated with heightened anxiety.

5.4.4 Impact of development and autism severity on subgroups of children with ASD on anxiety in relations to EF and SP dysfunctions

a. Overall impact of age, IQ and autism severity

Previous studies indicate anxiety increase with age in ASD (White et al, 2009, Green et al., 2011). Results of our cluster analyses showed that increasing age across childhood age is not consistently associated with heightened anxiety.

It was found however that heightened anxiety scores were frequently associated with higher IQ which supports previous work (Hallet et.al, 2013 & Sukhodolsky et al., 2008).

This finding is consistent in both the parents and child rated anxiety and supports previous literature that suggests cognitively higher functioning children experience more anxiety than lower functioning young people (White et al., 2010)

In terms of autism severity, it was found that autism severity seems to be more closely associated with sensory atypicalities than with anxiety per se supporting Kern et al. (2007b) who concluded that multi-sensory disturbance was positively associated with autism severity in children but weakened in adolescents and adults.

5.4.5. Summary of findings

This study was conducted for the purpose of capturing the heterogeneity in ASD and identifying subgroups of children with ASD, according to their anxiety

profiles and performance on executive functioning task and their SP abnormalities.

Results of cluster analyses indicate that subgroups of children exist based on their anxiety profile in relation to the influence of EF and SP dysfunctions, with significant heterogeneity in evidence across the sample. It appears that heightened anxiety scores are often associated with sensory atypicalities and that this occurs more frequently than associations with EF difficulties. When all variables are combined together with age, IQ and ASD severity, it was found that
anxiety issues are common in more able children with ASD and those with high ASD severity. Limitations, strength and suggestions for further study are discussed below.

5.4.6 Limitations and strengths

This is one of the first studies that has utilized cluster analytic techniques to explore subgroups of children with ASD according to their performance on EF and SP dysfunctions and anxiety. Results suggest that subgroups of children are identifiable and are characterized by different profiles of EF difficulties and SP atypicalities. This approach is essential and appropriate in determining groups of observations internally characterized by a high level of cohesion.

However, cluster analysis is a descriptive technique. The solution strongly depends upon the analyst's choices (experimenter bias). Cluster analysis will always derive a group structure even if there the associations are weak between the constructs. When applying a cluster analysis it is hypothesized that the groups exist. Therefore cluster analysis helps to reveal potential associations in data which require further exploration and verification. Cluster members share certain properties in common and thus the resultant classification will provide some insight into the constructs being studied.

Cluster analysis results also should not be generalized. Cases in the same cluster are (hopefully) similar only with respect to the information cluster analysis was based on (i.e., dimensions/variables inducing the considered

dissimilarities). To overcome this, data transformations and variable selections were undertaken before clustering. This will help to reduce the experimenter bias and certain degree of generalization can be made, though caution should be taken with interpretation.

This research also is the first to attempt utilizing neuropsychological approaches together with data related to sensory atypicalities and anxiety. The NEPSY-II (EF domain) was utilized to measure EF in this study. Even though there is still lack of empirical research on the subcomponents of EF functions and the factors they purported to measure (Miller, 2009), NEPSY-II is the first and the only neuropsychological battery developed specifically for children and adolescents.

There are some psychometric concerns with several of the subtests comprising the EF domain. Test retest correlations coefficients for subtest score in normative samples, for example, the Design fluency total score for age 5 to 12 were only
.59. (Korkman et al., 2007a). Reliabilities that fall below .70 should be approached with caution and below .60 are of significant concern. Furthermore, the correlation for the Animal Sorting subtest ranged from .08 to .24 suggesting that it may not measure the same construct as the other subtests of the domain. However, Korkman and colleagues account for the low correlations suggesting that various subtests are measuring different functions within the domain. Therefore, in this study, the combined EF scores was used as it was derived by combining two measures within the subtest (e.g., completion time and errors on the inhibition naming score).

The findings of this study contribute to the understanding of anxiety in ASD. When considering the findings, it is important to acknowledge the limitations of the study. Firstly the sample size is small, but comparable to other ASD study. Future studies should investigate anxiety profiles with a larger ASD sample and with a wider age and ability range. This is to allow replication of findings and begin to establish a robust developmental trajectory of anxiety profiles in children with ASD.

High functioning children with ASD have been reported to found to have elevated levels of anxiety symptoms (Hallet et al., 2013; Sukhodolsky et al., 2008 & Gilliot et al., 2001). The participants for this study all had ability within the average

range, it is therefore not possible for us to generalize these findings to less able young people with ASD. Future anxiety research should also target lower functioning children with ASD.

Reviews on anxiety measures in children with ASD demonstrate little consistency in terms of how anxiety symptoms were measured, and considerable variability in how respondents (e.g., parent, child) perceived such symptoms. In our study the parent and child rated SCAS was used as measure of anxiety symptoms in our participants. Wigham and McConachie (2014), did a two-stage systematic review aimed to identify the tools used in studies evaluating interventions for anxiety for high-functioning children with ASD in middle childhood, and then to evaluate the
tools for their appropriateness and measurement properties. Result show that three questionnaires were found robust in their measurement properties, the Spence Children's Anxiety Scale (SCAS), its revised version - the Revised Children's Anxiety and Depression Scale, and also the Screen for Child Anxiety Related Emotional Disorders. It is important to note however that despite utilising one of the more robust tools the SCAS has not been validated in ASD.

5.4.7 Suggestions for further study

This study was intended to explore anxiety in ASD by looking at the influence of EF difficulties and SP atypicalities. It utilized a broad age range of children (8-16 years) to allow for impact of development. The presence of subgroups suggests that further study is needed aiming to explore further in terms of the impact of difficulty in particular EF task in their daily lives.

This study was also purported to explore the profiles of association between anxiety subtypes and specific ASD phenotypes utilizing a broad age range of children (8-16 years) to allow for exploration of the impact of development. Within this sample, clusters of children were identified based on their performance on a range of measures. However this is an exploratory approach and does not allow inferences to be made. The presence of subgroups suggests that future studies should aim to explore this further.

5.5 Conclusions

The aim of this study was to determine whether subgroups of children can be identified within an ASD sample based on their profiles in relation to anxiety, executive functioning and sensory atypicalities, whilst taking into account other developmental characteristics such as age, ability and ASD severity. Results indicate that subgroups of children exist based on their profile on anxiety in relation to the influence of EF and SP dysfunctions. In addition, heightened anxiety scores in these subgroups of children with ASD are often associated with sensory atypicalities. This patterns occurs more frequently than associations with EF difficulties. When all variables are combined together with age, IQ and ASD severity, it was found that anxiety issues are common in more able children with ASD and those with higher ASD severity. These findings further denote the heterogeneity in autism as a condition that is characterized by deficits and atypicalities in patterns of cognitive, emotional, behavioural and social functioning that are manifested differently across subgroups of children.

Chapter 6. Exploring Specific Executive Dysfunctions (EDF) and Anxiety in ASD

6.1 Introduction

Executive functioning refers to higher order cognitive processes such as response initiation and selection, planning and strategy formation, cognitive flexibility and inhibition of prepotent response (Hill, 2004; Burgess and Shallice, 1996). It has been defined also as “the ability to maintain an appropriate problem-solving set for attainment of a future goal” (Welsh & Pennington, 1988).

Researchers have attempted to further specify the cognitive abilities described by this broad term, including planning, flexibility of thought and action, set-shifting, inhibition and holding a mental representation “on-line or in working memory (Griffith et al., 1999). Hill (2004) described ‘Executive function’ as an umbrella term for functions such as set-shifting and set maintenance, interference control, inhibition, integration across space and time, planning and working memory.

All these functions are typically affected following alterations in pre-frontal cortex functioning arising through acquired abnormalities such as tumors, infections and brain injury (e.g. Stuss and Benson, 1983; Tucha et al., 2000). However, impairments in executive functioning are also exhibited in neurodevelopmental disorders (Griffith et al., 1999).

Anxiety symptoms can interfere significantly with a child’s ability to participate in home, school, and community activities (Russell & Sofronoff, 2005). Children with significant anxiety symptoms are at risk for serious educational problems, later underemployment, substance abuse, and other psychiatric problems (Velting, Setzer, & Albano, 2004). Furthermore, some researchers note that anxiety problems can be especially “debilitating” to individuals with ASD (Greig & MacKay, 2005) by adversely impacting school performance, peer relationships, family functioning, and further exacerbating the core deficits of ASD (Bellini, 2004; Sze & Wood, 2007).

Despite growing knowledge about the prevalence, phenomenology and treatment of anxiety disorders, relatively little is understood about the nature and impact of anxiety in this group and little is known about autism-specific factors that may have a role in the increased risk for anxiety. Anxiety is a condition that cripples children's enjoyment of home and school life, preventing them from making friends and stifling their academic performance. In school life, Ashburner et al. (2010) compares teachers' perceptions of students with autism spectrum disorders (ASD) to their perceptions of typically developing students with regard to capacity to perform academically and regulate emotions and behaviour in mainstream classrooms. Teachers rated students with ASD as exhibiting behavioural and emotional difficulties (including attention difficulties, anxiety, depression, oppositional and aggressive behaviours) to a significantly higher level than their typically developing peers. Students with ASD (54%) were rated as under-achieving academically as compared to 8% of typically developing students. Students with ASD seem to be underperforming relative to their level of ability and are struggling to maintain their attention and regulate their emotions and behaviours in mainstream classrooms, despite receiving a range of specialist support services in the classroom.

In order to understand anxiety issues in ASD, Ozsivadjian et al. (2012) conducted series of five focus groups with 17 parents of children and adolescents with ASD and anxiety. Across groups, parents gave strikingly similar descriptions of the triggers and behavioural signs associated with anxiety and consistently reported that their children had great difficulty expressing their worries verbally and most showed their anxiety through changes in their behaviour. The impact of anxiety also was reported by parents to often be more substantial than the impact of ASD itself and parents also found it hard to distinguish between everyday worries and clinical anxiety levels. These issues make diagnosis difficult (*ibid*).

MacNeil et al. (2009) explored relationships among anxiety, loneliness, and degree of social skills deficits in a sample of youth with autism spectrum disorders (n = 20) aged between 7 and 14 years. Results suggest that those who self-reported elevated levels of anxiety reported greater feelings of social loneliness. A significant relationship between parent-reported child withdrawal and depression and social disability was also found.

Wood and Gadow (2010) explored nosology and pathogenesis of anxiety disorders in youth with autism and suggested that anxiety may play at least three roles: (a) a downstream consequence of ASD symptoms (e.g., via stress generation through social rejection); (b) a moderator of ASD symptom severity, such that certain core autism symptoms like social skill deficits and repetitive behaviours may be exacerbated by anxiety; and (c) as a proxy of core ASD symptoms.

One factor that leads to confusion for clinicians and researchers is the wide variability of characteristics within the autism spectrum. Recent developments in the field of ASD have led to a renewed interest in behavioural and neuropsychological markers underlying the spectrum of autism as part of a 'gold standard' approach to ASD diagnosis. One of these attempts is through exploring executive functions, and other features that might be associated with anxiety.

6.1.1 Executive Dysfunctions in Autism

Executive Dysfunctions (EDF) has become a prominent explanatory theory of the core symptoms present in autism. This theory was rooted back in 1978 when Damasio and Maurer compared the symptoms of autism to those of patients with injuries to the frontal lobes of the brain and impairments on tasks thought to tap "executive" skills or functions. Since that time research has demonstrated that deficits in executive functions are a feature of autism (Rogers & Pennington, 1991).

There are a few studies which attempt to identify intact and deficient cognitive processes in children with ASD. One of these studies compares EDF between children with attention deficit hyperactivity disorder (ADHD) and children with high functioning autism (HFA). The children were tested on a wide range of tasks related to five major domains of executive functioning (EF): inhibition, visual working memory, planning, cognitive flexibility, and verbal fluency. Results showed that children with HFA demonstrated deficits in all EF domains, except interference control and working memory (Geurts, Verté et al. 2004). Findings of this study indicate that children with HFA exhibit more generalized and profound

problems with EF tasks than children with ADHD. Findings of this study also suggest variability in EDF areas across subgroups of children with ASD which. This further indicates that there are wide variations in the manner and severity that the different EDF areas affected in autistic children.

Executive dysfunction appears to consistently involve disruptions in task-oriented behavior, which requires executive control in the inhibition of habitual responses and goal activation. Such executive control is responsible for adjusting behaviour to reconcile environmental changes with goals for effective behaviour (Nieuwenhuis et al., 2004). Impairments in set shifting ability are a notable feature of EDF whereby difficulties in set shifting impaired the ability to dynamically change focus between points of fixation based on changing goals and environmental stimuli (Avila et al., 2003). This offers a parsimonious explanation for the common occurrence of impulsive, hyperactive, disorganized, and aggressive behaviour in clinical patients with EDF.

In order to understand why EDF has been proposed to explain the deficits in autism, it is important to first examine the EDF areas that specifically affect children with autism, as this will lead to further understanding of the difficulties faced by children with ASD in their daily lives. Individuals with autism commonly show impairments in three main areas of executive functioning, Fluency, Planning and Flexibility (e.g. Gilotty et al., 2002; Barnard et al., 2008 & Hill, 2004). However, in terms of fluency, findings from studies with well-matched control groups (e. g. Turner, 1997 & 1999; Jarrold et al. (1994) have identified that autistic children has difficulty with verbal and ideational fluency as well as with pretend play indicating that these impairments arise from difficulty in generativity (Hill, 2004).

a. Planning.

Planning refers to a complex, dynamic process, where in a sequence of planned actions must be developed, monitored, re-evaluated and updated (Hill, 2004). Children with autism demonstrate impairments on tasks requiring planning abilities relative to typically functioning controls, with this impairment maintained over time (Ozonoff & McEvoy, 1994). As might be suspected, in the case of

autism comorbid with learning disability, an additive deficit is observed in many cases (Croen et al., 2002).

b. Generativity

Children with autism also have difficulties to generating novel ideas and responses spontaneously (Turner, 1997). These deficits may underpin the lack of spontaneity and initiative (Lewis & Boucher, 1991), poverty of speech (fluency) and action (Boucher, 1988) and failure to engage in pretense (Jarrold et al, 1994) seen in some individuals with ASD. Research also has suggested that children with autism generate fewer novel words and ideas and produce less complex responses than matched controls (Turner, 1999). Impairment in verbal fluency subtests have been attributed to the relatively low processing speed found in this group (Spek et al., 2009).

c. Flexibility.

Poor mental flexibility, as demonstrated in individuals with autism, is characterized by perseverative, stereotyped behaviour, and deficits in both the regulation and modulation of motor acts (Hill, 2004). Some research has suggested that children with autism experience a sort of 'stuck-in-set' perseveration that is specific to the disorder, rather than a more global perseveration tendency (e.g. Hughes et al., 1994). These deficits have been exhibited in cross-cultural samples (e. g. Shu et al., 2001) and have been shown to persist over time (Hill, 2004).

d. Self-monitoring

Self-monitoring is the ability to monitor one's own thoughts and actions, as well as to self-correct those thoughts and actions (Hill, 2004). Little evidence has been found with regards to specific self-monitoring deficits in children with autism with respect to matched controls (Hill & Russell, 2002; Russell & Hill, 2001). Therefore, there is mixed evidence in terms of impairment in self-monitoring among children with autism.

Although there has been some debate about deficits in inhibition among individuals with autism, it is generally no longer considered to be an executive function deficit in people with autism (Barnard et al., 2008, Hill, 2004). Some authors suggests that executive function tests that demonstrate a clear rationale

are passed by individuals with autism (Hill, 2004).Therefore, it is the design of the measures of inhibition that have been implicated in the observation of impaired performance rather than inhibition being a core deficit.

6.1.2 The impact of Executive Dysfunctions on Daily Life

There are a few investigations that aim to show a relationship between deficits in executive function and the everyday behavioural difficulties that may originate from them. Mackinlay et al. (2006) suggests that children with high functioning autism often experience difficulties organizing goal-directed actions in their day-to-day lives, requiring support to schedule daily activities. They captured these everyday difficulties experimentally using multitasking, a methodology that taps into the cognitive processes necessary for successful goal-directed activities in daily life. They investigated multitasking using the Battersea Multitask Paradigm. 14 high functioning children with ASD and 16 typically developing controls, matched for age and IQ participated. Findings indicate that children with ASD were less efficient at planning, attempted fewer tasks, switched inflexibly between tasks and broke performance rules more frequently than controls.

Gilotty et al. (2002) found that deficits in executive processes may contribute to the problems with reciprocity in social interactions that characterize children with autism. In terms of academic performance and participation, Zingerevich and Patricia (2009) describe the contribution of executive functions to participation in school activities of children with ASD. They have found that executive dysfunctions contribute to difficulties participating in school activities, particularly the abilities to resist impulsive responses, to stop a behaviour at the appropriate time, and to regulate emotional responses.

Deficits in flexibility and planning have been found consistently in children with ASD on EF measures (Ozonoff, 1998). Rumsey (1985) suggests that successful social functioning and similarly executive functioning involves integration and weighing of multiple contextual variables, selective attention and inductive logic. Furthermore, Gioia (2002) found a significant relationship between social skills and executive function as measured by parent report. Thus, deficits in executive

processes may contribute to the problems with reciprocity in social interactions that characterize children with ASD. In the following section, the relationships among anxiety symptoms and executive dysfunctions in children with ASD will be discussed.

In order to explore the impact of EF difficulties on daily lives and whether there may be an influence of other core characteristics of ASD with anxiety, it is necessary to firstly examine the development of executive functions in ASD.

6.1.3 The development of Executive functions in ASD

Executive function is an umbrella term for functions such as planning, working memory, impulse control, inhibition and mental flexibility, as well as for the initiation and monitoring of action (Hill, 2004). Anderson (2010) described the developmental profile of executive processes across childhood. They proposed a developmental model of EF by incorporating four discrete but inter-related executive domains (attentional control, cognitive flexibility, goal setting, and information processing) which operate in an integrative manner to enable "executive control". They also found that attentional control appears to emerge in infancy and develop rapidly in early childhood. In contrast, cognitive flexibility, goal setting, and information processing experience a critical period of development between 7 and 9 years of age, and are relatively mature by 12 years of age. A transitional period is thought to occur at the beginning of adolescence, and shortly after "executive control" is likely to emerge. Findings of this study shed light to our current understanding of EF development and further enhance our understanding of brain-behaviour relationships.

The primacy of executive dysfunction in autism is a topic of much debate and attempts to examine subtypes of executive function within autism implicate frontal lobe function. Hill (2004) reviewed cognitive behavioural studies of planning, mental flexibility and inhibition in autism and concluded that more detailed research is needed to fractionate the executive system in autism by assessing a wide range of executive functions as well as their neuroanatomical correlates in the same individuals across the lifespan. Findings of this study indicates that studies in executive functioning should focus on assessing wide range of different EF functions.

6.1.4 The impact of Executive Dysfunctions on Daily Living

Mackinlay et al. (2006) suggests that children with high functioning autism often experience difficulties organising goal-directed actions in their day-to-day lives, requiring support to schedule daily activities. They captured these everyday difficulties experimentally using multitasking, a methodology that taps into the cognitive processes necessary for successful goal-directed activities in everyday life. They investigated multitasking in these group of children using the Battersea Multitask Paradigm. 14 high functioning children and 16 typically developing controls, matched for age and IQ participated. Findings indicate that children with ASD were less efficient at planning, attempted fewer tasks, switched inflexibly between tasks and broke performance rules more frequently than controls.

There are a few investigations being done in order to show a relationship between deficits in executive function and the everyday behavioural difficulties that may originate from them. Gilotty et al. (2002) found that deficits in executive processes may contribute to the problems with reciprocity in social interactions that characterize children with autism. In terms of academic performance and participation, Zingerevich and Patricia (2009) describe the contribution of executive functions to participation in school activities of children diagnosed with ASD. They have found that executive dysfunctions contribute to difficulties participating in school activities, particularly the abilities to resist impulsive responses, to stop a behaviour at the appropriate time, and to regulate emotional responses.

Deficits in flexibility and planning have been found consistently in children with ASD on EF measures (Ozonoff, 1995). Rumsey (1985) suggests that successful social functioning and similarly executive functioning involves integration and weighing of multiple contextual variables, selective attention and inductive logic. Furthermore, Gioia (2002) found significant relationship between social skills and executive function as measured by parents report. Thus, deficits in executive

processes may contribute to the problems with reciprocity in social interactions that characterize children with ASD.

6.1.4 Neuropsychological correlates of anxiety and EF

A small number of studies have compared executive functioning profiles between children with ASD and those with an anxiety disorder. Thede and Coolidge (2007) compared children with high functioning autism and Asperger syndrome on parent report measures of psychological and executive functioning. Both groups showed greater deficits than control groups on executive function and furthermore children with Asperger had higher scores on obsessive-compulsive, avoidant and depressive personality scales.

Individuals with OCD often report that they recognize the senselessness of their obsessions but are still compelled to engage in rituals or cannot dismiss the obsessional idea reference needed (Greisberg and McKay 2003). This difficulty has been linked to problems with cognitive control (Rachman & Hodgson, 1980) and has been considered part of impaired functioning in the frontal lobes which are often associated with difficulties in executive functioning (Lezak, 1995). Greisberg and McKay (2003) examined neuropsychological features of obsessive-compulsive disorder (OCD) and findings of this study point towards deficits in organizational strategies in general, suggesting problems in executive functioning. It is also suggested that the interaction between organizational strategy deficits and the effort to recall unstructured information contributes to 'doubting' which is an important feature of OCD (*ibid*).

In another study, Zandt et al. (2009) studied neurocognitive patterns of functioning in both ASD and Obsessive Compulsive Disorders. Executive functioning (EF) impairments were hypothesized in both ASD and Obsessive Compulsive Disorders. Performance on neuropsychological tests assessing executive functioning showed a trend for children with ASD to perform poorly on tasks requiring generation of multiple responses, while children with OCD tended to demonstrate impairments on a task requiring inhibition. Parental ratings on a

questionnaire measure of EF indicated impairments in both groups relative to typically developing controls.

Given that ASD is associated with the presence of both EF deficits and anxiety, a next logical step is to explore whether there are important relationships between these two features of the disorder and whether anxiety and EF deficits are also associated with other core characteristics of ASD. Restricted, Repetitive Behaviours (RRB) have been extensively investigated as having relationship with both anxiety and EF in ASD. The following section will discuss RRB in more detail.

6.1.5 Executive Dysfunctions and anxiety in ASD

Studies in the neuropsychological correlates of anxiety suggest that poor executive functioning is associated with high prevalence of anxiety disorders in children and adolescents with ASD (Hollock et al. 2014). Findings of this study also suggest that future research is required to specify the nature of the relationship between executive functioning and anxiety in ASD.

There have been several theoretical attempts to explain the effects of anxiety on cognitive performance. One leading theory in anxiety is Attentional Control theory (Eysenck et al., 2007), which suggests that anxiety disrupts the balance in the top-down attentional control system and bottom-up stimulus-driven attentional systems. Attentional control theory also suggests that anxiety impairs the efficiency of two executive functions; the inhibition and shifting functions (Eysenck and Derakshan 2011). Most of the research findings on specific EF deficits in ASD, point towards impairments in cognitive flexibility (e.g. Lopez et al., 2005). Research in children with an anxiety disorder suggests an association between reduced performance on tasks of executive functioning such as attentional switching and verbal working memory (Gunther et al., 2004 & Toren et al., 2000).

Findings of our study (see Chapter 4) of the influence of executive and sensory processing (SP) dysfunction on anxiety in ASD suggests that executive dysfunction is not consistently associated with anxiety. In this study, we utilized cluster analysis in order to examine the profile of the relationships. Parent and child rated anxiety scores were used in examining patterns of relationships with a total EF score. Results of the cluster analysis of parent rated anxiety identified five clusters of children showing varying EF characteristics in relation to their anxiety profiles. 16 children showed heightened anxiety score making up 2 clusters. One of these clusters represented a group of children (n=7) who demonstrated the highest anxiety score and EF was below expected levels. In contrast, one cluster of children (n=9) showed heightened anxiety score but EF above the expected level. On the child rated anxiety score, results of the cluster analysis identified five clusters of children who showed varying anxiety profiles. 2 clusters (n=20) showed high anxiety scores, but their profile on EF are varied (some show EF at expected level and some at below expected level).

Consistent with parent rated anxiety, results of the cluster analyses of the child rated anxiety also indicated that heightened anxiety is not always related to EF difficulties in a consistent way. Some children who have high anxiety have higher level of EF difficulties, whilst some show relative low EF difficulties when anxiety is high.

The previous study intended to explore anxiety in ASD by looking at the influence of EF difficulties generally, alongside SP atypicalities. The previous study used an EF composite score which may mask the contribution of specific EF subtypes to the development of anxiety for these children. Specific EF subtypes will therefore be examined in this study.

Individuals with ASD represent a diverse clinical group, which often makes diagnosis and intervention for anxiety quite difficult. Individuals with ASD and an anxiety disorder present with particularly complex behaviours that require a unique approach to treatment (Tantam, 2000). Research focusing on neuropsychological features of anxiety disorders points towards possible deficits in organizational strategies in general, suggesting problems in executive functioning. Results of investigations into neuropsychological functioning have

been inconsistent so far. Several studies with participants with OCD suggest impairment on tests of set shifting, fluency, planning and problem solving and visuospatial memory. The majority of studies suggest that OCD is commonly associated with mild cognitive dysfunction on tasks involving executive functioning and nonverbal memory (e.g. Greisberg & McKay, 2003; Kuelz, Hsohagen & Voderholzer, 2004a).

6.1.6 Restricted, Repetitive and stereotyped Behaviour (RRB) in ASD

Restricted, repetitive, behaviours (RRB) are a core feature of autism, along with the social and communication problems (American Psychiatric Association, 2013). The term repetitive behaviours is an umbrella term used to refer to the broad and often disparate class of behaviours linked by repetition, rigidity, invariance and inappropriateness (Turner, 1999). Studies of the neuropsychological correlates of autism suggest that the cognitive deficits and the symptoms are fundamentally related, whether or not the deficit is autism-specific (Turner & Russell, 1997). In addition, the growing evidence for executive deficits in autism has led to the suggestion that executive dysfunction may be of primary importance to the autistic syndrome (e.g. Hill, 2004).

An important prediction of any causal account, is that any variance in the degree and nature of the deficit will be associated with variability and severity of the symptomatology that is suggested to stem from this deficit. There has been some attempt to validate and test these predictions. Turner and Russell (1997) reviewed these associations and found that perseveration on a set-shifting task was correlated with more primitive stereotyped behaviours such as hand flapping while impoverished generativity was correlated with higher level repetitive behaviours such as circumscribed interest. Findings of this study suggest a relationship between repetitive behaviour and executive functioning. They also suggest that repetitive behaviour may follow from impaired functioning of executive processes.

In another study examining the relationship between EF and RRB, executive function theory was utilized to examine the relationship between cognitive

processes and the restricted, repetitive symptoms of Autistic Disorder (Lopez, et al., 2005). Seventeen adults with AD were compared to 17 non-autistic controls on Delis-Kaplan Executive Function Scales. Findings of this study replicated the executive function profile that has been reported in adults with autism. The study also found several executive processes (i.e., cognitive flexibility, working memory, and response inhibition) were highly related to the restrictive, repetitive symptoms of Autistic Disorder. Whereas, other executive process (i.e., planning and fluency) were not found to be significantly correlated with restricted, repetitive symptoms.

In contrast to the above study which involved adults with ASD, South et al. (2007) examined the relationship between everyday repetitive behaviours and performance on neuropsychological tests of executive function and central coherence in children with ASD. Participants included 19 individuals (aged 10 to 19) with high functioning autism spectrum disorders (ASD group) and 18 age and IQ matched typically developing controls (TD group). Result shows partial support in the ASD group in terms of relationship between repetitive behaviour and executive performance (on the Wisconsin Card Sorting Task).

Leekam et al. (2011) did an extensive review on the potential causal origins and triggers for RRB. In terms of neuropsychological correlates, they found that children with ASD appear to have poor regulation and control. However the cognitive impairments of response inhibition, set shifting, generativity, planning, and their associations with repetitive behaviour frequency have not been firmly established. They suggest it is likely that neurocognitive functioning is a consequence rather than a cause of RRB, since all behavioural aspects of autism are both affected by and also affect the level of neurocognitive development.

Loftin et al. (2008) found that students with autism have difficulty initiating social interactions and may exhibit repetitive motor behaviour. Teaching new skills may lead to reductions in problem behaviour, such as motor stereotypies which helps to increase social interaction. The author also found that self-monitoring strategies can help to improve the maintenance of skills. Using a multiple baseline design, the author examined whether multi-component social skills

intervention such as peer training, social initiation instruction, and self-monitoring led to a decrease in repetitive motor behaviour. They found that social initiations was increased when taught to initiate, and social interactions continued when self-monitoring was introduced. Furthermore, participants' repetitive motor behaviour was also reduced. The improvement in social behaviour and in repetitive motor behaviour were maintained more than one month after the intervention ended.

6.1.6 Anxiety in relation to Executive Dysfunction and Repetitive Behaviour (RRB)

There are a few studies which attempt to understand the links between repetitive behaviours and anxiety. Rodgers et al. (2012a) did a cross syndrome comparison between children with Autism Spectrum Disorder (n=34) and Williams syndrome (n=20) in terms of anxiety profiles. They compared anxiety in both of the syndromes and also examined the relationship between repetitive behaviours and anxiety. Children with autism were found to have higher levels of anxiety and within the autism sample, higher levels of repetitive behaviours were associated with more anxiety. This was not replicated in the Williams Syndrome sample, indicating a differential role for restricted and repetitive behaviours in relation to anxiety in ASD.

In another study, Rodgers et al. (2012b) examined repetitive behaviours and anxiety in two groups of children with autism spectrum disorder, those with high anxiety scores and those with lower levels of anxiety. Results showed that the children with high anxiety had more repetitive behaviours. Within the anxiety sample, higher levels of insistence on sameness were associated with more anxiety. These findings further indicate a differential relationship for repetitive behaviours in relation to anxious and non-anxious children with ASD.

Zandt et al. (2007) compared children with Autism Spectrum Disorders (ASD) and children with Obsessive Compulsive Disorder (OCD) on a range of repetitive behaviours. Parents reported similar levels of sameness behaviour and repetitive movements in the clinical groups, although children with OCD engaged in more repetitive behaviour focussed around routines and rituals. Children with OCD

reported more compulsions and obsessions than children with ASD; both groups reported more compulsions and obsessions than a typically developing comparison group. Types of compulsions and obsessions tended to be less sophisticated in children with ASD than those with OCD. Sameness behaviour was more prevalent in younger children with OCD, but for children with ASD, age was not significantly related to sameness behaviour, repetitive movements, compulsions, or obsessions. Findings indicates that OCD is one of the commonest types of anxiety in ASD.

Further study on underlying neurocognitive processes in repetitive behaviour was undertaken by Zandt et al. (2009) among children and adolescents (aged 7 to 16 years) with ASD and obsessive compulsive disorder (OCD). They were compared on a range of executive function (EF) measures. Performance on neuropsychological tests assessing executive functioning showed a trend for children with ASD to perform poorly on tasks requiring generation of multiple responses, while children with OCD tended to demonstrate impairments on a task requiring inhibition. Parental ratings on a questionnaire measure of EF indicated impairments in both groups relative to controls. Relationships between questionnaire and performance measures of EF were generally weak. There was some limited support for a relationship between EF and repetitive behaviour, but effects tended to be small and variable across groups and measures.

Finally, Wigham et al. (2014) examined pathways between sensory abnormalities and RRB, and the role anxiety and IU. They utilized caregiver report involving 53 children with ASD aged 8–16 years. Results shows significant association between both the sensory under responsiveness (SUR) and sensory over responsiveness (SOR) with repetitive motor and insistence on sameness behaviours. The relationships also was significantly mediated by IU and anxiety.

6.1.7 Executive Dysfunctions and Obsessive Compulsive Disorder (OCD)

Research on anxiety in ASD, suggests that social phobia, social anxiety (Bellini, 2004; 2006) and OCD (Zandt et al., 2007; 2009) are the most consistently

occurring specific anxiety problems. Furthermore, variability in neuropsychological correlates depends on the specific anxiety disorder being studied; panic disorder with and without agoraphobia and obsessive–compulsive disorders were found to be the most strongly related to impairments in both episodic memory and executive functioning (Airaksinen et al., 2005).

Mack et al. (2010) compared the clinical characteristics and symptom severity of children with OCD plus ASD with those of children with OCD plus Tourette's syndrome (TS) or OCD alone. They found that participants from the OCD/ASD group rated their OC symptoms as equally distressing, time consuming and contributing to a similar level of interference in functioning as patients in the OCD/TS and OCD groups. Patients with OCD/ASD reported more peer relationship problems compared with the other two groups.

Individuals with OCD also often report that they recognize the senselessness of their obsessions but are still compelled to engage in rituals or cannot dismiss the obsessional idea (Greisberg and McKay 2003). This difficulty has been linked to problems with cognitive control (Rachman & Hodgson, 1980) and has been considered part of impaired functioning in the frontal lobes which are often associated with difficulties in executive functioning (Lezak, 1995).

Greisberg and McKay (2003) examined neuropsychological features of obsessive-compulsive disorder (OCD) and findings of this study point towards deficits in organizational strategies in general, suggesting problems in executive functioning. It is also suggested that the interaction between organizational strategy deficits and the effort to recall unstructured information contributes to ‘doubting’ which is an important feature of OCD (*ibid*).

A small number of studies have compared executive functioning profiles between children with ASD and those with an anxiety disorder. Zandt et al. (2009) studied neurocognitive patterns of functioning in both ASD and Obsessive Compulsive Disorders. Performance on neuropsychological tests assessing executive functioning showed a trend for children with ASD to perform poorly on tasks requiring generation of multiple responses, while children with OCD tended to

demonstrate impairments on a task requiring inhibition. Parental ratings on a questionnaire measure of EF indicated impairments in both groups relative to typically developing controls. Given these findings particular attention will be given to OCD in the current study.

6.1.8 Limitations of current findings

There are mixed findings in terms of the relationship between EF and anxiety.

Due to the nature of executive functioning as an umbrella name for subcomponents such as inhibition of learned and automatic responses, monitoring and self-regulation, vigilance, selective and sustained attention, the capacity to establish, maintain and change a response set, non-verbal problem solving, planning and organizing a complex response; and figural fluency (Korkman et al., 2007a), cluster analysis should also consider the subtests that compose the EF rather than just a total combined score. Indeed a review of EF research needs to consider discriminant validity and autism specificity. Functions generally distinguish ‘normal’ from ‘abnormal’ but are not specific indicators that distinguish one syndrome to another (Ozonoff et al., 2005). It appears that different neurodevelopmental disorders are associated with different profiles of strengths and weaknesses in EF. Therefore, their explanatory power is diminished and discriminant validity may be ‘more apparent than real’ (Hughes, 2001). Thus, further research should consider EF as a multidimensional rather than a unitary construct in order to obtain more precision in the nature of the dysfunctions associated with autism.

Research indicates that OCD is one of the most common types of anxiety in ASD and relationship between EF and OCD has been found. Greisberg and McKay (2003) suggested that the interaction between organizational strategy deficits and the effort to recall unstructured information contributes to doubting, which is an important feature of OCD. Further study examining underlying neurocognitive process in children with ASD and specifically with symptoms of obsessive compulsive disorder (OCD) is needed in order to ascertain these associations.

Turner (1997, 1999) has suggested that executive dysfunction may be responsible for the stereotyped, repetitive behaviours of Autism Spectrum

Disorders. A strong relationship between cognitive flexibility and repetitive behaviours was also reported by Lopez et al. (2005). In contrast to the above study which involved adults with ASD, South et al. (2007) shows partial support in the ASD group in terms of relationship between repetitive behaviour and executive performance in children with ASD. The sample of this study was significantly older (mean age = 14) and more intellectually capable (mean VIQ = 111) than Turner's sample which make direct comparison is difficult which indicated that further research is needed in order to examine the consistency of these findings.

Therefore, in terms of neuropsychological correlates, children with ASD appear to have poor regulation and control. However the cognitive impairments of response inhibition, set shifting, generativity, planning, and their associations with repetitive behaviour frequency have not been established (e.g. Leekam, 2011). Therefore further investigations is needed to ascertain the associations and whether the similar findings is replicated.

Research on Obsessive Compulsive Disorder (OCD) and RRB in children with ASD indicates that OCD is one of the commonest types of anxiety in ASD. Greisberg and McKay (2003) suggested that the interaction between organizational strategy deficits and the effort to recall unstructured information contributes to doubting, which is an important feature of OCD. Further study examining underlying neurocognitive processes in repetitive behaviour among children and adolescents with ASD and anxiety and more specifically with symptoms of obsessive compulsive disorder (OCD) reported that there was some limited support for a relationship between EF and repetitive behaviour.

Performance on neuropsychological tests assessing executive functioning showed a trend for children with ASD to perform poorly on tasks requiring generation of multiple responses, while children with OCD tended to demonstrate impairments on a task requiring inhibition (Zandt 2007, 2009). Therefore the essential step for future studies is to explore and ascertain the relationship between anxiety generally, OCD specifically, EF and RRB in order to explore the neuropsychological correlates between these three variables.

6.1.9 Aims of Study

In this study we are primarily interested to explore the associations between specific EF subtypes and anxiety. Given the significant relationship between of OCD and ASD and between OCD and specific EDF areas, we are also interested to examine the relationship between particular EF tasks and OCD characteristics in children with ASD.

6.2 Methodology

6.2.1 Design

This study has a cross sectional design and uses the same methodology as described in chapter 4. Therefore, reference to chapter 4 will be made wherever appropriate throughout the methods sections in this chapter.

6.2.2 Participants and recruitment

The 36 parents and young people with ASD participated. Kindly refer to Chapter 4 for detailed descriptions of the sample.

6.2.3 Measures

a. Developmental NEuroPSYcological Assessment –Version II (NEPSY-II; Korkman et al. 2007)

Kindly refer to chapter 4 for details descriptions of this measure.

b. The Spence Children's Anxiety Scale-SCAS (Spence, 1998)

This measure was completed by all participants at the earlier testing phase and was re-administered to the parents in this study. Kindly refer to Chapter 4 for details descriptions of this measure.

c. Behaviour Rating Inventory of Executive Function (BRIEF: Gerard et al. 2000)

The BRIEF measures impairment of executive function behaviours in the school and home environments. This questionnaire was developed for parents and teachers of school-age children. It is designed to assess the abilities of a broad range of children and adolescents. It also measures different aspects of a child or adolescent's behaviour, such as his or her ability to control impulses, move freely from one situation to the next, modulate responses, anticipate future events, and keep track of the effect of his or her behaviour on others.

The BRIEF has eight clinical scales (Inhibit, Shift, Emotional Control, Initiate, Working Memory, Plan/Organize, Organization of Materials, and Monitoring) and two validity scales (Inconsistency and Negativity) which provide a well-rounded picture of the behaviour of the child being rated. The clinical scales form two broader indexes (Behavioural Regulation and Metacognition) and an overall score, the Global Executive Composite.

The BRIEF has high internal consistency (alphas = .80-.98) and test-retest reliability (rs = .82 for parents, .88 for teachers) were found (Gerard et al., 2000). It has specific normative data based on age and gender as well as separate normative tables for parent and teacher forms provide T scores, percentiles, and 90% confidence intervals for four developmental age groups by gender of the child. The Parent Form of the BRIEF contains 86 items that measure different aspects of executive function. It takes 10-15 minutes to administer and 15-20 minutes to score.

d. The Repetitive Behaviours Questionnaire (RBQ; Turner 1995)

The RBQ is a 33-item questionnaire short-form of the Repetitive Behaviour Interview (RBI: Turner, 1995) and being used to measure repetitive behaviour. Parents are required to rate the behaviours for severity or frequency on a 3 or 4 point Likert scale depending upon the behaviour. A higher score indicates more severe or frequent RRB. Behaviours examined include repetitive movements, sameness behaviour, repetitive use of language and circumscribed interests. A

validation study by Honey et al. (2012) identified two reliable and valid factors; sensory motor factor and insistence on sameness or circumscribed interests in ASD. The total RBQ score and the two factor scores are reported.

e. The Children's Obsessional Compulsive Inventory – revised (CHOCI-R; Uher et al., 2008)

The CHOCI-R is a self- and parent-report questionnaire designed to assess the content and severity of OCD symptoms in children and adolescents (Shafran et al., 2003). It follows the format of the CY-BOCS interview. The CHOCI-R has two sections: (A) compulsions and (B) obsessions, each comprising 16 questions. Each section starts with 10 questions about the presence of common OCD symptoms, with a three option response format ('not at all' = 0, 'somewhat' = 1, 'a lot' = 2). The symptom items serve to focus the subsequent severity ratings on OCD symptoms as well as produce symptom scores for obsessions (10 items, score range 0–20), compulsions (10 items, score range 0–20), and total (20 items, score range 0–40), reflecting the complexity and pervasiveness of OCD symptomatology.

In each section, the symptom items are followed by six questions with five-option response format (scored 0–4) probing the severity and impairment associated with OCD symptoms. Severity items include time spent with the symptoms, interference with functioning, distress, resistance, control and avoidance. Severity scores (obsessions, compulsions and total) can be obtained by summing up all item responses. The 'obsessions impairment' (6 items, score range 0–24) and 'compulsions impairment' (6 items, score range 0–24) scores were combined to produce the 'Total Impairment Score' (12 items, score range 0–48), which is designed to be comparable to interview-based CYBOCS total score.

The CHOCI has good internal consistency, criterion validity and significantly correlates with the Children's Yale-Brown Obsessive Compulsive Scale (CY-BOCS; Scahill et al., 1997). In comparison with other commonly used scales, for example Leyton Obsessional Inventory, Child Version (LOI-CV; Berg, Whitaker,

Davies, Flament & Rapoport, 1988) and CY-BOCS, CHOCI was found to be superior. The items to assess symptoms were based on a revision of the Maudsley obsessional compulsive inventory (Thordarson, Rachman, & Radomsky, 1996), and were rated on a three-point scale of 1–3 corresponding to 'not at all', 'somewhat' and 'a lot.'

In this study, the Parent version of CHOCI was used (Uher et al., 2008). The scale takes approximately 15 minutes to administer and 5 minutes to score. The total score for both the symptoms and severity sections for was reported. Higher score on the Parent version of CHOCI-R indicates higher OCD symptoms. The classification of the total score on the self-report version of the CHOCI-is as follows: 0-11 is sub-clinical levels of OCD; 12-23 is mild; 24-37 is moderate and 38 or more is severe OCD. However, for the parent version, there are no specific classifications available. They only provide the equivalent scores table for parent version (a few points higher) as parents appear to rate their children more severely (*Ibid*). (See the Equivalent Score Table on **Appendix B**).

6.2.4 Examining the use of the Child Obsessional Compulsive Inventory (CHOCI) with children with ASD

a. Overview

Obsessional, ritualistic, stereotyped and repetitive behaviours are the core feature of autistic disorders, co-occurring with communication difficulties and problems in social interaction (DSM-V; APA, 2013). Autism-related obsessive-compulsive phenomena (AOCP) are part of the clinical picture in ASD (Kanner, 1943).

Measuring anxiety in young people with ASD can present a considerable challenge as symptoms of anxiety and features of ASD can be overlapping and make it difficult to differentiate (MacNeil et al., 2009). Obsessions and compulsions in Obsessive-Compulsive Disorders (OCD) and Autism-related obsessive-compulsive phenomena (AOCP) are often regarded as an overlapping class of behaviours (Fischer-Terworth and Probst, 2009) and the repetitive and

ritualistic behaviours inherent in ASD can be difficult to tease apart from the compulsive behaviours in OCD (Gjevik et al., 2010).

The parent version of CHOCI-R is a valid measure used to assess symptoms of obsessions and compulsions in children. It was developed with typically developing children. The norms for the parent version of CHOCI-R were developed based on 330 (203 boys and 127 girls) OCD children. They were referred children and adolescents to the specialist clinic for child and adolescent obsessive–compulsive disorder in the years 2000–2006 at National Clinic for Young People with OCD, South London and Maudsley NHS Trust, London (Uher et al., 2008). They were asked to complete the CHOCI-R questionnaire prior to clinical assessment. Referred children and adolescents were eligible if they (i) received a diagnosis of OCD according to ICD-10 criteria (WHO, 1992) established in a structured clinical interview with parents and the child, (ii) provided data on either self- or parent-report CHOCI-R.

b. Semantic evaluation on the parent version of CHOCI-R

It could be the case that some OCD symptoms might be interpreted as RRBs by parents of young people with ASD, when they are completing the measure because there is similarity between the ways in which RRB might present in ASD and obsessions and compulsions might present in people with OCD without ASD. If this was the case this would artificially inflate the COCHI scores for young people with ASD.

Therefore, we are interested in determining whether when considering the items in relation to children with ASD some of the items may be interpreted as representative of the restricted and repetitive behaviours, which are a characteristics of ASD, rather than OCD symptoms per se.

In order to determine whether some items are more likely to be considered as representing RRB when thinking about a child with ASD consultation was undertaken with an expert panel. Should any items be consistently rated as being representative of RRB rather than OCD those items were removed from the scale before analysis was undertaken. The assumption here is that the remaining items will be more likely to be characteristics of OCD in this ASD sample.

c. Aims

The primary aim of this exercise is to determine which items in the P-CHOCI may represent characteristics of RRB or features of OCD in children with ASD.

d. Methodology

Participants

Participants for this exercise were 21 experts in the field of autism (both clinicians and researchers), including pediatricians, child and adolescent psychiatrists, clinical psychologists and researchers.

Inclusion and exclusion

This is a convenience sample participants were experts who attended either a research or clinical team meeting in the North East of England during April and May 2013.

e. Measures

The Children's Obsessional Compulsive Inventory - revised (CHOCI-R; Uher et al., 2008)

The CHOCI-R is a valid self-report and parent report measure of OCD severity. It has been used and validated in young people aged 9-17. The scale therefore contains items related to symptoms and severity for both compulsion and obsessions.

The CHOCI-R has two sections: (A) compulsions and (B) obsessions, each comprising 16 questions. Each section starts with 10 questions about the presence of common OCD symptoms, with a three option response format (‘not at all’ = 0, ‘somewhat’ = 1, ‘a lot’ = 2). In each section, the symptom items are followed by six questions with five-option response format (scored 0–4) probing the severity and impairments associated with OCD symptoms. Severity items

include time spent with the symptoms, interference with functioning, distress, resistance, control and avoidance.

In this study, the Parent version of CHOCI was used. In this exercise, the items on the symptom section for both compulsion and obsessions were used. Therefore, only 10 items from the compulsion section and another 10 items from obsession item were used, which made a total of 20 items.

The ten items on the compulsion section asked about things or "habits" their son/daughter feels they have to do although they may know that they do not make sense. Sometimes, s/he may try to stop doing them but this might not be possible. Their son/daughter might feel worried or angry or frustrated until s/he has finished what s/he has to do. Another ten items are from the obsession section. Each of the questions asks about thoughts, ideas, or pictures that keep coming into their son's/daughter's mind even though s/he does not want them to do so. They may be unpleasant, silly, or embarrassing.

The expert raters were required to evaluate whether they thought the items best reflected OCD characteristics, RRBs features or whether it was unclear. It took the raters approximately 10 minutes to rate all the 20 items. The expert raters were given the following instructions:

"Thinking about children with ASD, please look at each item and consider whether you think that item best reflects:

a) OCD characteristics

b) or RRB features or

c) you are unclear

We are interested in any comments you may have so please note down any comments in the space provided".

If any individual item was endorsed by more than 75% of raters as representing RRB rather than OCD this item was removed from the scale prior to further analysis being undertaken.

f. Data analysis

Descriptive data analysis was utilized to obtain the frequency and percentage of experts' responses for each item.

g. Results

Descriptive Results

The following table shows frequency of experts rating as to whether the item represent OCD, RRBs or is unclear.

Table 6.1

Frequency of rating from experts for OCD, RRB or unclear item

No.	Items	OCD	RRB	Unclear
1.	My son/daughter spends far too much time washing his/her hands over and over again.	17	0	4
2.	My son/daughter feels s/he must do ordinary/everyday things exactly the same way, every time s/he does them.	2	11	8
3.	My son/daughter spends a lot of time every day checking things over and over and over again.	9	3	9
4.	My son/daughter often has trouble finishing things because s/he needs to make absolutely sure that everything is exactly right.	7	5	9
5.	My son/daughter spends far too much time arranging his/her things in order.	2	12	7
6.	My son/daughter needs someone to tell him/her things are alright over and over again.	8	7	6
7.	If my son/daughter touches something with one hand, s/he feels s/he absolutely must touch the same thing with the other hand, in order to make things even and equal.	16	4	1
8.	My son/daughter always counts, even when doing ordinary things.*	4	8	8

9.	If my son/daughter has a 'bad thought', s/he always has to make sure that s/he immediately have a 'good thought' to cancel it out	19	0	2
10.	My son/daughter is often very late because s/he keeps on repeating the same action, over and over again.	4	5	12
11.	My son/daughter can't stop thinking upsetting thoughts about an accident.	9	0	12
12.	My son/daughter often has bad thoughts that make him/her feel like a terrible person.	16	0	5
13.	Upsetting thoughts about the family being hurt go round and round in my son's/daughter's head and stop him/her from concentrating.	18	1	2
14.	My son/daughter always has big doubts about whether s/he has made the right decision, even about stupid little things	11	3	7
15.	My son/daughter can't stop upsetting thoughts about death from going round in his/her head, over and over again.*	14	1	6
16.	My son/daughter often has mean thoughts about other people that s/he feels are terrible, over and over again.	17	0	4
17.	My son/daughter often has horrible thoughts about going crazy.	9	0	14
18.	My son/daughter keeps on having frightening thoughts that something terrible is going to happen and it will be his/her fault.	5	0	16
19.	My son/daughter is very frightened that s/he will think something (or do something) that will upset God	11	0	10
20.	My son/daughter is always worried that his/her mean thoughts about other people are as wicked as actually doing mean things to them	14	0	7

*1 missing/no rating for item 8 and 15

In order to describe the findings of this exercise systematically, the above frequency was converted into percentages. The above items were grouped into three in order facilitate better descriptions:

a. Group 1 (Item 1-7)

b. Group 2 (Item 8-14)

c. Group 3 (Item 15-20)

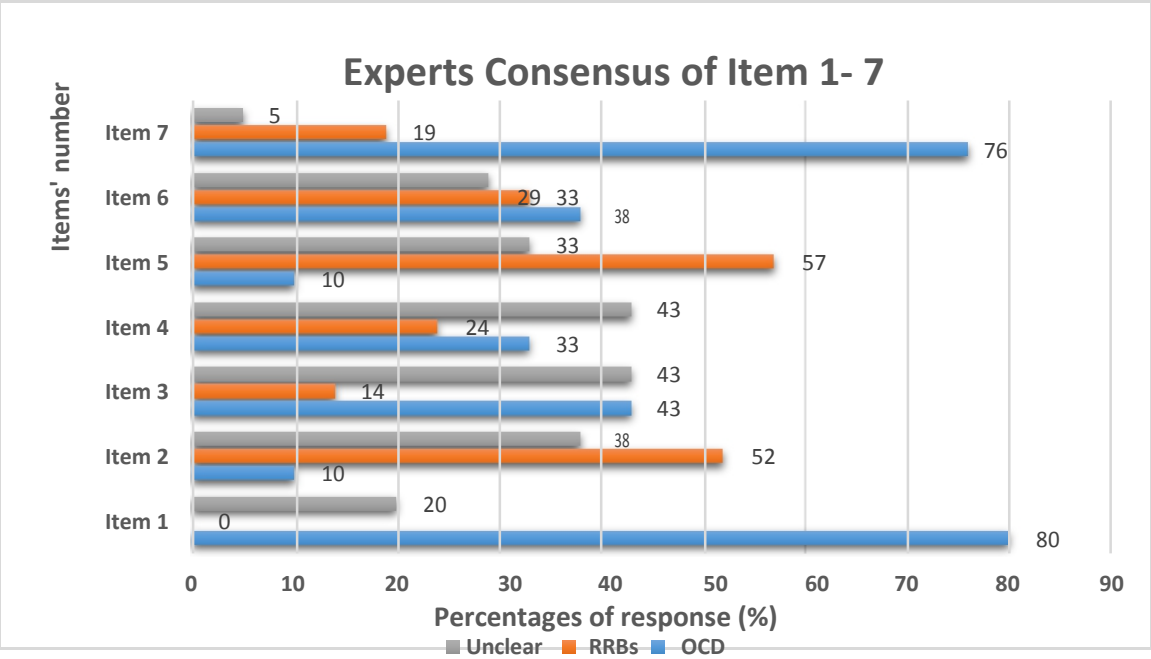
The following section will describe the percentages of expert consensus on PCHOCI items according to the grouped items.

a. Group 1 (Item 1-7)

The following figure (figure 1) represents expert consensus on item 1 until 7 as to whether they think that these items best reflects OCD characteristics, or RRB features or they are unclear whether this item represent any of it.

Figure 6.1

Experts Consensus of Item 1 until 7



From the above figure, it was found that items 2 and 5 has very low expert consensus that these items represent OCD.

Only 10% (n=2) of experts rated item two (My son/daughter feels s/he must do ordinary/everyday things exactly the same way, every time s/he does them), as representing OCD. Another 52 % (n=11) think that this item represents RRBs. The rest of the experts (38%; n=8) think that it is unclear whether it represent OCD or RRBs.

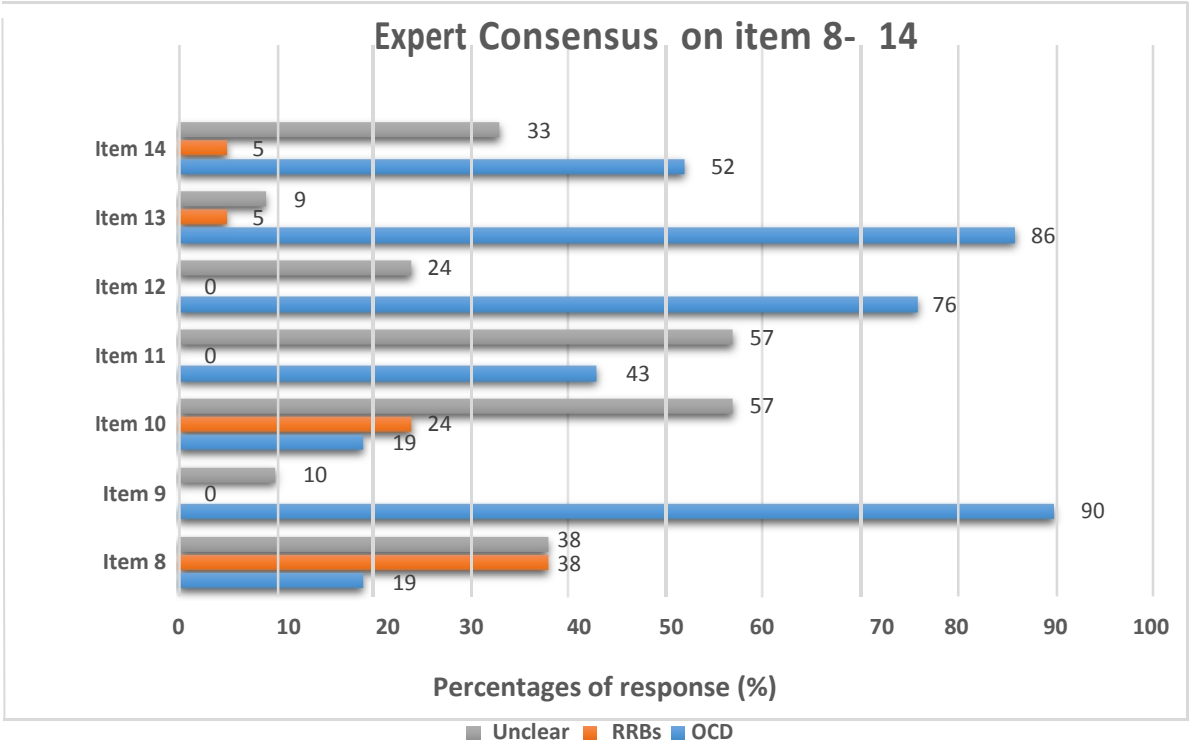
On item 5 (My son/daughter feels s/he must do ordinary/everyday things exactly the same way, every time s/he does them), only 10 % (n=2) of the expert think that this item reflects OCD characteristics. 57% (n=12) of the experts rated that this item represent RRBs and another 33% (n=7) think that it is actually unclear whether it represents OCD or RRBs. Therefore, 90% (n=19) of the experts think that this item does not represent the OCD characteristic. Therefore, these two items will be removed from the analysis.

Group 2 (Item 8-14)

The figure below (figure 6.2) represents expert consensus on item 8 until 14 as to whether they think that these items best reflect OCD characteristics, or RRB features or they are unclear.

Figure 6.2

Experts Consensus of Item 8 until 14



From the above figure, it was found that item 8 and 10 has very low expert consensus that these items represent OCD.

On item eight (My son/daughter always counts, even when doing ordinary things) only 19% (n=4) of the experts think that this item reflects OCD, another 76 % (n=16) of them feels that this item either reflect RRBs or they are unclear about it. As for item 10 (My son/daughter is often very late because s/he keeps on repeating the same action, over and over again), 19% (n=4) of the experts feels that this item represent OCD characteristics. Another 81% (n=11) of experts think that this item best reflects either RRBs features or unclear whether it represents OCD and RRBs characteristics.

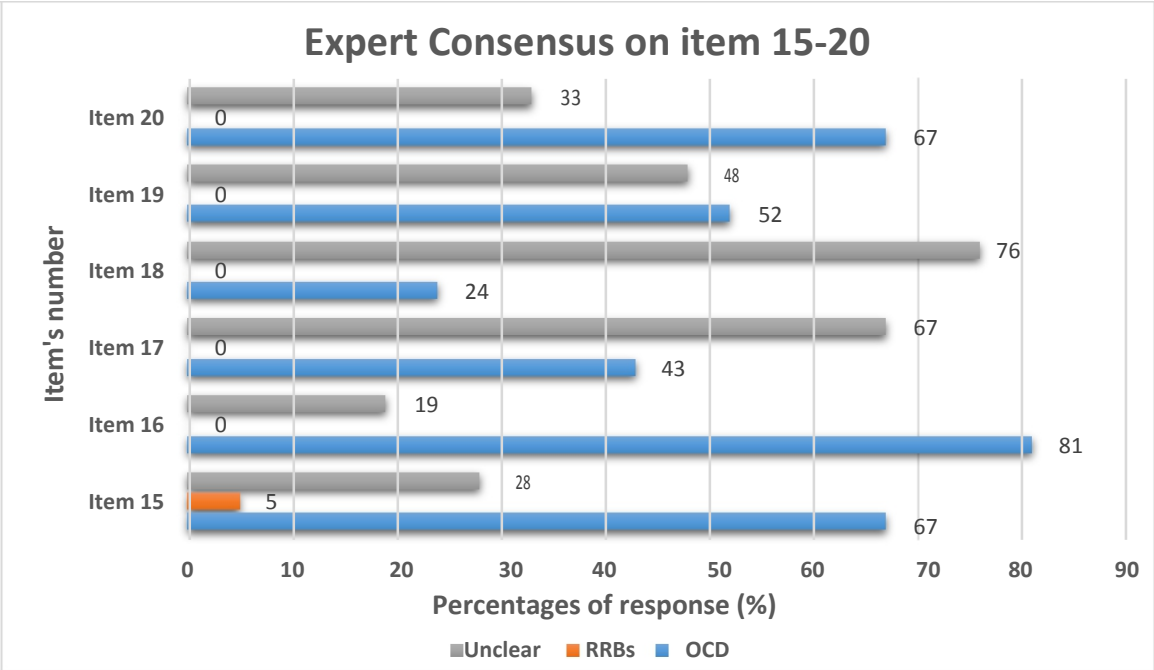
These two items (8 and 10) will be removed from the analysis.

Group 3 (Item 15-20)

The following figure below (figure 6.3) represents expert consensus on items 15 to 20 as to whether they think that these items best reflects OCD characteristics, or RRB features or they are unclear.

Figure 6.3

Experts Consensus of Item 15 until 20



From the above figure, it was found that item 18 has very low expert consensus that this item represent OCD.

Only 24% (n=5) of experts rated item 18 (My son/daughter keeps on having frightening thoughts that something terrible is going to happen and it will be his/her fault) as representing OCD item. None of the experts think that this item represents RRBs. The rest of the expert (76 %; n=16) think that it is unclear whether it represent OCD and RRBs. Given that this item was not identified as an RRB item however this item will be retained.

f. Summary

Item 2, 5, 8, 10 were rated by experts as less representative of OCD characteristics and more likely to be an RRB when considering a child with ASD. Therefore these items will not be included in the analysis.

6.2.5 Main Procedure

Kindly refer to chapter 4 for detailed description of the procedure for this study.

6.2.5 Data Analytic Technique

a. Cluster Analysis

The selection of variables for analysis was based on previous literature on anxiety and executive dysfunction theory of autism. Kindly refer to chapter 5 for details of this analytic technique.

b. Basis for Cluster Analysis in this study

The following factors have been considered in order to form the basis for cluster analysis in this study:

Exploring cluster solutions using key variables as predicted by the existing evidence of their potential associations between EF subtests, anxiety and OCD in ASD.

Based on the cluster solutions that emerged, group membership across variables was explored in order to identify the profiles of any indicated group.

Multiple analyses were run to achieve the aims of study. The level of analysis that involved was as follows:

Firstly, all the EF subtests except the Inhibition-Naming (INN) and Inhibition-Inhibition (INI) were loaded with parent and child rated anxiety scores in order to observe how each specific EF function was associated with the other variables.

Secondly, the relationship between EF subtests and parent rated CHOCI-R was explored. All the EF subtest except the Inhibition-Naming (INN) and Inhibition-Inhibition (INI) were loaded together with the total score of parent rated CHOCI-R scores.

In our study, only the combined scale scores of the Inhibition-Switching (INS) was used to represent the Inhibition function in EF. This is due to the fact that Inhibition in the NEPSY-II was represented by three tasks namely Inhibition

Naming (INN), Inhibition-Inhibition (INI) and Inhibition-Switching (INS). The inhibition subtest was designed to assess multiple aspects of EF including inhibitory control, cognitive flexibility and self-monitoring. There are many scores available on the inhibition subtest that may be considered in the interpretation and the use of all scores is not required (Korkman et al., 2007). Therefore, in our study, the Inhibition-Switching (INS) was used to represent the Inhibition function in EF as it represents inhibitory functions such as inhibitory control and cognitive flexibility.

6.3 Results

6.3.1 Descriptive statistics

Table 6.2

Participant descriptive statistics on all measures

N=36	Mean	SD	Range	Cronbach's alpha
NEPSY-II subtests				
AS Combined Score	5.34	1.75	2-10	
AA Combined Score	7.64	4.44	1-15	
RS Combined Score	9.48	3.78	1-14	
CL total score	9.21	5.81	1-19	
DF total score	7.53	3.74	1-16	
INS Combined score	9.79	4.24	1-15	
SCAS scores				
Parent Rated SCAS total score	33.00	17.28	1-68	**.737**
Child Rated SCAS total score	35.86	18.68	0-77	**.760**

Key: NEPSY-II - Developmental NEuroPSYcological Assessment –Version II; AS – Animal Sorting; AA – Auditory Attention; RS – Response Set; CL – Clock; DF – Design Fluency; INS – Inhibition Switching; SCAS – The Spence Children's Anxiety Scale

6.3.2 Cluster Analysis

The first stage of cluster analysis involves identification of subgroups children with ASD on anxiety scores, according to their performance on EF subtests. This analysis utilizing both direct and parental report measures purported to assess anxiety in ASD and the influence of Executive Dysfunctions (EDF).

a. Relationship between parent rated anxiety and EF subtests

To explore these relationships, the total combined score for each of the EF subtests of the NEPSY-II, except the Inhibition-Naming (INN) and Inhibition-Inhibition (INI) were loaded to ClustanGraphic data files together with the parent rated SCAS. The parent rated SCAS scores were loaded first and later being replaced by the child rated. Eight cluster solutions were found to be significantly different from random patterns (figure 6.4) and mean cluster scores for all the variables are as per table 6.3. Figure 6.5 shows MDS scaling which illustrates cluster members in relations to anxiety.

Figure 6.4

ClustanGraphics dendogram illustrating significant five cluster solutions (cluster analysis 1).

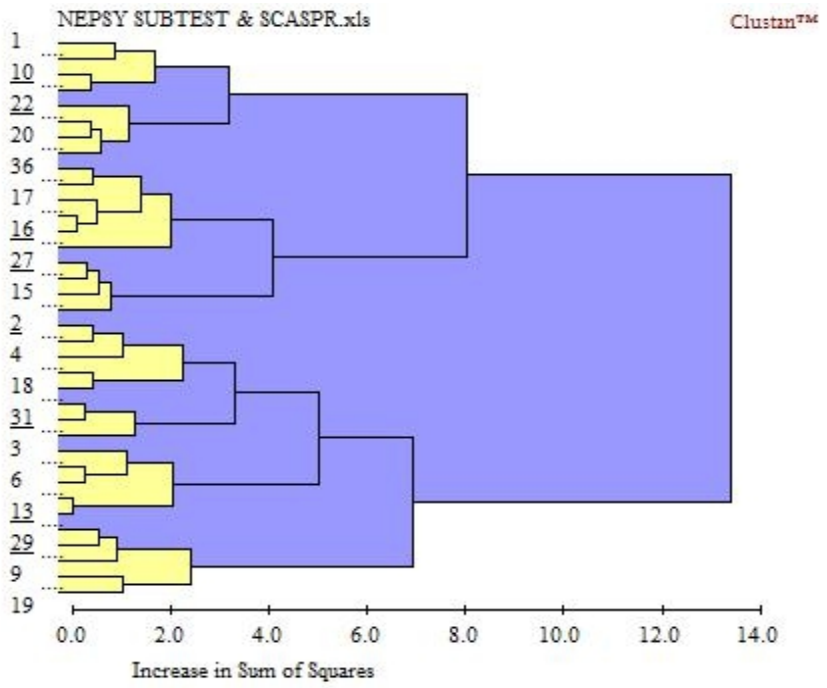


Table 6.3

Mean cluster scores for EF subtest and parent-rated anxiety.

Cluster	N	AS score	AA score	RS score	CL score	DF score	INS score	SCAS-P total score
1	4	7.75**	11.00	12.50	16.00	10.00	12.00	44.50*
2	4	5.50**	11.50	13.00	13.25	8.75	7.00**	15.67
3	6	3.67**	12.00	11.80	6.40**	11.20	13.75	23.20
4	4	4.00**	8.50	9.75	5.75**	8.75	11.75	54.00*
5	5	5.40**	4.60**	5.00**	13.20	6.60**	12.60	27.20
6	3	4.67**	2.33**	3.67**	1.00**	4.67**	9.33	37.00*
7	5	7.75**	4.50**	10.25	3.50**	5.50**	9.25	19.00
8	5	4.80**	5.60**	9.00	11.60	4.20**	3.40**	44.60*

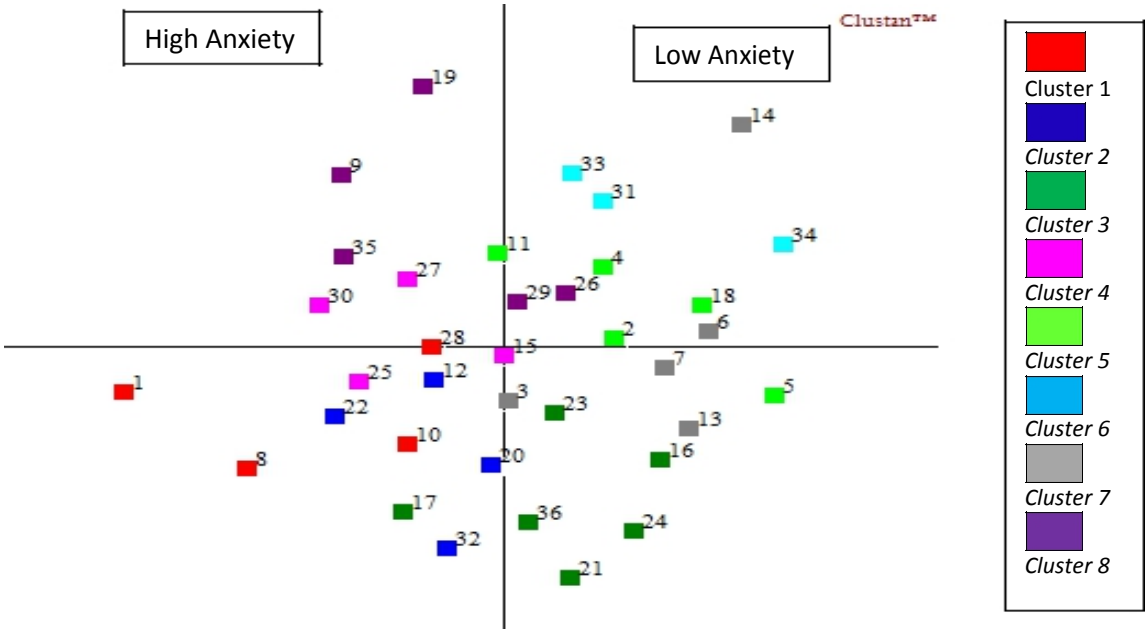
**Anxiety score above indicative clinical cut-off mean*

***Indicative of low EF subtest score (below expected level)*

Key: AS – Animal Sorting; AA – Auditory Attention; RS – Response Set; CL – Clock; DF – Design Fluency; INS – Inhibition Switching

Figure 6.5

ClustanMDS illustrates cluster members in relations to high/low of anxiety scores. Description of clusters



Cluster 1: Children in cluster 1 (n=4) have mean anxiety scores above the clinical cut-off and low AS (Animal sorting) subtest score. A low score in this subtest suggests poor initiation, cognitive flexibility and self-monitoring abilities. Other EF functions are at expected level.

Cluster 2: This cluster represents four children who have anxiety scores above clinical cut-off. This group of children also present with poor AS subtest scores and also have low INS subtest which indicates poor inhibition abilities.

Cluster 3: The six children in this cluster shows anxiety scores below indicative clinical cut-off, they have impaired AS and CL subtests. Impairment on the AS subtests indicates that they have poor initiation, productivity and cognitive flexibility. Whereas low CL subtests, reflects poor planning and organization.

Cluster 4: This cluster represents four children who have high anxiety scores above clinical cut-off mean. These children have low AS and CL subtests which suggests poor initiation, productivity and cognitive flexibility as well as poor planning and organization abilities.

Cluster 5: Cluster 5 consists of five children who have low anxiety scores, low AS, AA, RS and DF subtests. Low scores on AS subtests indicate that they have poor initiation, cognitive flexibility and self-monitoring. On the AA subtests, low scores reflect poor selective and sustained attention. Low scores on RS subtest suggest poor selective and sustained attention as well as inhibition. Low score on this subtest also may indicate poor working memory. Another subtest that has low score is DF. Low score on this subtest is indicative of poor initiation and productivity as well as poor cognitive flexibility.

Cluster 6: Children in this cluster (n=3) have anxiety scores slightly above clinical cut-off. In terms of EF subtests, they have low AS, AA, RS, CL and DF scores. Low scores on AA demonstrate that they have poor initiation, cognitive flexibility and self-monitoring. On the RS subtest, low scores indicate poor selective and sustained attention as well as inhibition. Low score on this subtest also may indicates poor working memory. As for CL subtests, low score reflects

poor planning and organization. Low DF scores on the other hand suggest poor initiation and productivity as well as poor cognitive flexibility.

Cluster 7: Cluster 7 consists of five members. These children demonstrate anxiety scores below the clinical cut-off. . They have impaired AS, AA, RS, CL and DF. Poor scores on AS subtests indicate that they have poor initiation, cognitive flexibility and self-monitoring abilities. Another subtest that has a low score is the AA. Low score in this subtest reflects poor selective and sustained attention as well as response inhibition. On the RS subtest, low scores indicate poor selective and sustained attention as well as working memory. CL subtest also fall within low category which suggest poor planning and organization. On the DF subtest low score is indicative of poor initiation and productivity as well as poor cognitive flexibility.

Cluster 8: The five children in this cluster have high anxiety scores (above clinical cut-off) and also demonstrate low AS, AA, DF and INS subtest score. Low score on AS subtest suggest of poor initiation, cognitive flexibility and self-monitoring abilities. On the AA subtest, low score is indicative of poor selective and sustained attention as well as response inhibition. On the DF subtest low score is indicative of poor initiation and productivity as well as poor cognitive flexibility. These children also have low INS subtest which indicates poor inhibition abilities.

Overall description

In summary, children in clusters 1, 4, 6 and 8 (n=16) have high anxiety scores (mean above the indicative clinical cut-off). These subgroups of children are also characterized by low EF subtest scores. The AS subtest in particular, was consistently impaired on all these four clusters which indicates these children also have poor initiation, cognitive flexibility and self-monitoring abilities.

Children in cluster 8 (n=8), have the highest anxiety score and low EF scores on four of the EF subtests (AS, AA, DF and INS). Children in cluster 6 (n=3) also have high anxiety scores and low scores on five subtests (AS, AA, RS, CL and DF). These findings indicates that for these children there may be a relationship

between EDF and anxiety. However, this is not the case for all clusters that have heightened anxiety scores. For instance, children in cluster one (n=4) have low EF score only on the AS subtest and in cluster 4 (n=4) the children have low EF score only on the AS and CL subtests. Furthermore, other clusters that have low anxiety scores, have EF subtest scores that are also low (cluster 3, 5 and 7; n=16).

Further examination of the other EF subtests (AA, DF, CL, RS and INS), revealed that low scores on these subtests are also related to heightened anxiety scores. This suggests that for some children heightened anxiety may be associated with poor selective and sustained attention, planning and organization, selective and sustained attention, working memory and also inhibition difficulties. However, difficulties in these EF abilities are not consistently found across all clusters which have heightened anxiety scores [AA, and DF (cluster 6 and 8; n=8), CL (cluster 4 and 6; n=7), RS (cluster 6; n=3) and INS (cluster 8; n=5)].

These findings suggests that there is no consistent relationship between EDF subtypes, no candidate EF type which accounts for heightened anxiety in all children with ASD, though having EF difficulties does appear to confer vulnerability to anxiety though there may be different routes to anxiety for different children with ASD.

b. Relationship between child rated anxiety and EF subtests

The next level of analysis is exploring the relationship between child rated anxiety and EF subtest scores. The EF subtest scores were subjected to ClustanGraphics together with the child rated SCAS total scores. Figure 6.6 shows the ClustanGraphics dendogram illustrating eight cluster solutions. Table 6.4 shows the mean cluster scores for the EF subtests and child-rated anxiety and Figure 6.7 shows MDS scaling which illustrates cluster members in relations to anxiety.

Figure 6.6

ClustanGraphics dendogram illustrating significant five cluster solutions (cluster analysis 2).

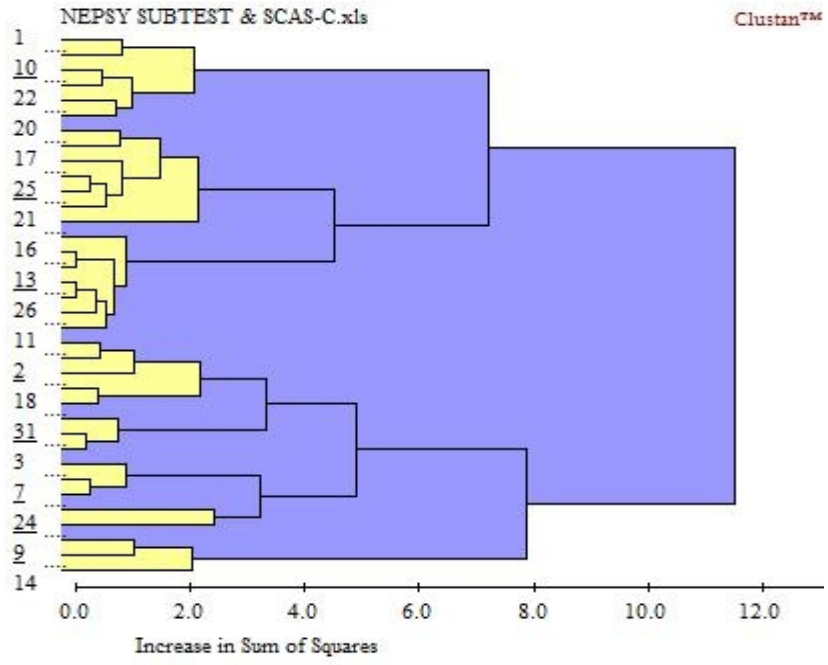


Table 6.4

Mean cluster scores for EF subtest and child-rated anxiety.

Cluster	N	AS score	AA Score	RS score	CL score	DF score	INS score	SCAS-C total score
1	6	7.33**	10.67	12.67	15.50	9.67	10.33	39.00*
2	7	4.14**	10.71	10.71	8.14	11.71	12.50	48.57*
3	7	4.00**	9.60	10.60	7.80**	5.00**	8.00	38.57*
4	5	5.40**	4.60**	5.00**	13.20	6.60**	12.60	19.00
5	3	4.67**	2.33**	3.67**	1.00**	4.67**	9.33	30.67
6	3	7.33**	5.00**	11.33	4.33**	6.67**	12.00	22.33
7	2	3.50**	10.50	13.50	7.00**	6.00**	7.00**	2.50
8	3	6.67**	2.33**	7.00**	9.33	4.00**	1.67**	62.67*

**Anxiety score above indicative clinical cut-off mean*

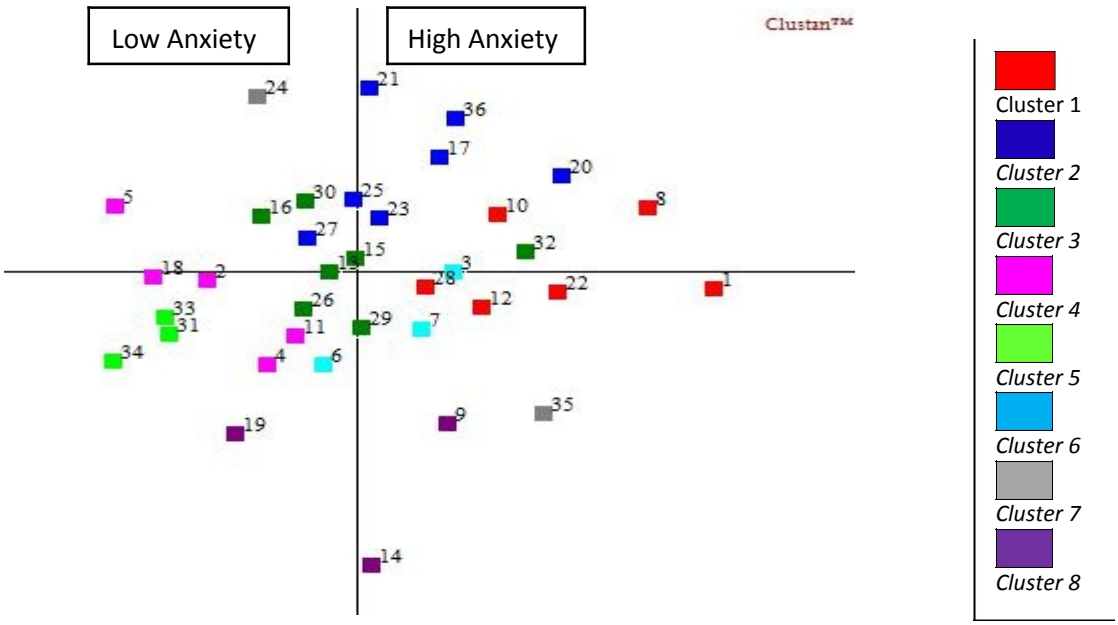
***indicative of low EF subtest score (below expected level)*

Key: AS – Animal Sorting; AA – Auditory Attention; RS – Response Set; CL – Clock; DF – Design Fluency; INS – Inhibition Switching

Description of clusters

Figure 6.7

ClustanMDS illustrates cluster members in relations to high and low anxiety scores.



Cluster 1: Children in cluster 1 (n=6) have anxiety scores slightly above the indicative clinical cut-off and impaired AS which indicates poor initiation, cognitive flexibility and self- monitoring abilities.

Cluster 2: Cluster 2 represents children (n=7) with high anxiety scores, impaired AS and CL which indicates poor initiation, cognitive flexibility and self-monitoring as well as planning and organization abilities.

Cluster 3: This cluster represents five children who show anxiety scores slightly above the clinical cut-off, low AS, CL and DF subtests scores. Low scores on these subtests indicates poor initiation, cognitive flexibility and self-monitoring, poor planning and organizations as well as impaired initiation and productivity abilities.

Cluster 4: The five children in this cluster have low anxiety scores (below indicative clinical cut-off) and low AS, AA, RS, and DF subtests. This reflects that these children have poor initiation, cognitive flexibility and self-monitoring,

selective and sustained attention, working memory and impaired initiation and productivity abilities.

Cluster 5: Children in this cluster (n=3) have low anxiety score, impaired AS, AA, RS, CL and DF. This indicates that these children have poor initiation, cognitive flexibility and self-monitoring, poor selective and sustained attention, working memory, planning and organizations as well as impaired initiation and productivity abilities.

Cluster 6: The three children in this cluster have low anxiety scores and low scores on AS, AA, RS, CL and DF subtests. This indicates that these children have poor initiation, cognitive flexibility and self-monitoring, poor selective and sustained attention, working memory, planning and organizations as well as impaired initiation and productivity abilities.

Cluster 7: Children in this cluster (n=2) have the lowest anxiety score and low scores on AS, CL, DF and INS subtests. This demonstrates that these children have poor initiation, cognitive flexibility and self-monitoring, planning and organizations, impaired initiation and productivity as well as inhibition abilities.

Cluster 8: The three children in this cluster have the highest anxiety score and low AS, AA, RS, DF and INS subtests. Low scores on these subtests are indicative of poor initiation, cognitive flexibility and self-monitoring, selective and sustained attention, working memory, impaired initiation and productivity as well as inhibition abilities.

Overall interpretation

As a summary, children in cluster 1, 2, 3 and 8 (n=23) have high anxiety scores and low AS scores in all the clusters. This suggests that these subgroups of children are characterized by high anxiety coupled with poor initiation, cognitive flexibility and self-monitoring abilities. Further examination of other clusters,

however reveals that the AS subtest is consistently in the low range even when anxiety scores are low. This indicates that the presence of impairment in initiation, cognitive flexibility and self-monitoring is not consistently associated with anxiety.

Cluster 8 (n=3) has the highest anxiety scores and is the most impaired cluster in terms of EDF (low AS, AA, RS, CL, and DF), however this is not the case for all clusters that have heightened anxiety. For instance, cluster 1 and 2, only have low EF scores on AS subtests. Furthermore, on clusters that have low anxiety scores we also see low scores on several EF subtests (cluster 4: AS, AA, RS and DF; cluster 5: AS, AA, RS, CL and DF; cluster 6: AS, CL, DF and INS).

The above findings also suggest that a low score on a range of EF subtests are associated with heightened anxiety, but like the findings from the analysis based on parent report there appears to be no one candidate subtest which can account for heightened anxiety

6.3.4 Relationship between EF subtests and OCD

a. Descriptive result

Table 6.5

Participant descriptive statistics on OCD measure

N=36	Mean	SD	Range	Cronbach's alpha
Parent Rated CHOCI-R total score	22.32	5.78	16-38	**.884**

Key: CHOCI-R - The Children's Obsessional Compulsive Inventory – brief version.

b. Cluster Analysis result

The previous analysis was based on total anxiety scores which are produced as a composite score of all of the subscales of the SCAS. In this second stage of cluster analysis, the relationship between EF subtests and parent rated CHOCI-R

was explored. This analysis is purported to examine the underlying neurocognitive process in children with ASD between EDF and symptoms of obsessive compulsive disorder (OCD).

In this second stage of analysis, there are two level of analysis. Firstly between all the EF subtests and the long version of parent rated CHOCI-R (original version) and secondly between the EF subtests and the short version of parent rated CHOCI-R (after the overlapping items were removed). In this section, only the result of cluster analysis between the EF subtests and the short version of parent rated CHOCI-R will be reported. The results and interpretations of cluster analysis on the EF subtests and the long version of parent rated CHOCI-R are as per **Appendix I.**

As for cluster analysis between the EF subtests and the short version of parent rated CHOCI-R, all the EF subtests except the Inhibition-Naming (INN) and Inhibition-Inhibition (INI) were loaded together with the total score of the short version of parent rated CHOCI-R. Figure 6.8 shows ClustanGraphics dendogram illustrating six cluster solutions. Table 6.6 shows mean cluster scores for EF subtest and OCD and Figure 6.9 shows MDS scaling which illustrates cluster members in relations to anxiety.

Figure 6.8

ClustanGraphics dendogram illustrating significant five cluster solutions (cluster analysis 3)

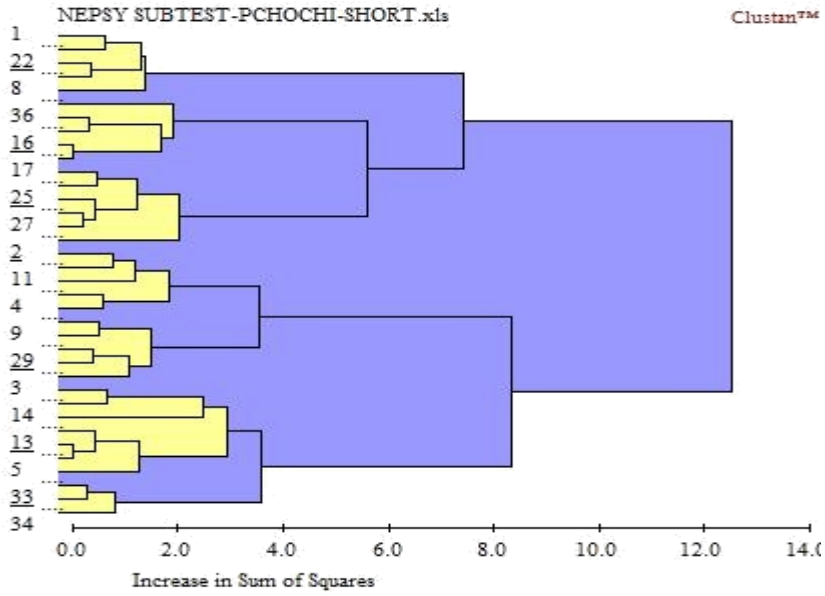


Table 6.6

Mean cluster scores for EF subtest and OCD symptoms.

Cluster	N	AS score	AA score	RS score	CL score	DF score	INS score	PCHOCI score
1	5	7.40**	12.40	12.40	14.60	11.00	10.40	21.75
2	5	3.80**	13.75	12.25	4.75**	10.00	10.67	17.20
3	6	3.83**	8.83	10.50	8.17	9.33	12.50	27.80
4	5	5.20**	6.00**	8.60	14.20	3.80**	11.40	26.40
5	5	5.20**	5.40**	9.80	13.00	5.80**	2.80**	22.40
6	7	7.00**	4.33**	7.50**	5.50**	7.17**	10.83	18.71
7	3	4.67**	2.33**	3.67**	1.00**	4.67**	9.33	23.33

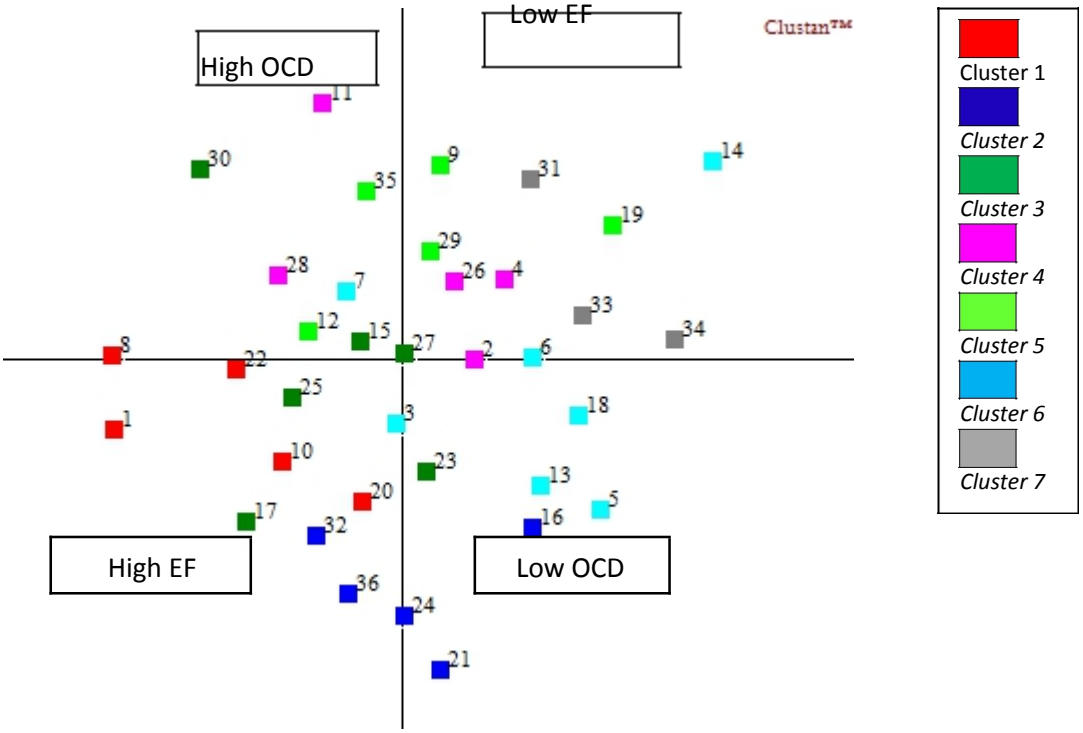
***Indicative of low EF performance (below expected level)*

Key: AS – Animal Sorting; AA – Auditory Attention; RS – Response Set; CL – Clock; DF – Design Fluency; INS – Inhibition Switching; PCHOCI – Parent rated Children Obsessive Compulsive Inventory (Short version)

Description of clusters

Figure 6.9

ClustanMDS illustrates cluster members in relations to high and low of EF abilities and OCD symptoms.



Cluster 1: Children in cluster 1 (n=5) have low OCD and low AS subtest scores which indicates poor initiation, cognitive flexibility and self-monitoring.

Cluster 2: Cluster 2 represents five children who demonstrate low OCD scores and the lowest AS score. This suggest that these children have poor initiation, cognitive flexibility and self-monitoring.

Cluster 3: This cluster represents six children who show high OCD scores and very low AS subtest scores. This indicates that these children have poor initiation, cognitive flexibility and self-monitoring.

Cluster 4: The five children in this cluster have high OCD scores, low AS, AA and the lowest DF subtest. This indicates that they have poor initiation, cognitive flexibility and self-monitoring, selective and sustained attention and impaired initiation and productivity.

Cluster 5: This cluster represents by five children who have low OCD scores and poor AS, AA DF and INS subtests. This suggests that they have poor initiation, cognitive flexibility and self-monitoring, selective and sustained attention, impaired initiation and productivity and inhibition abilities.

Cluster 6: This cluster represents by five children who have high OCD scores and low AS, AA, RS and CL subtest. They have the lowest AA and RS subtests. Low score in these subtests indicates that they have poor initiation, cognitive flexibility and self-monitoring, selective and sustained attention, working memory, planning and organizations abilities.

Cluster 7: This cluster represents by three children who have low OCD scores and poor AS, AA, CL and DF subtests. They are having the lowest AA and CL subtest. This indicates that they have poor initiation, cognitive flexibility and self-monitoring, selective and sustained attention, working memory, planning and organizations ability and impaired initiation and productivity.

Overall interpretation

Children in cluster 3 and 4 (n=11) demonstrate high OCD symptoms and low AS subtest scores in both clusters. Low scores on AS subtest, suggests poor initiation, cognitive flexibility and self-monitoring abilities in EF. Therefore, there is an indication that poor abilities in these EF functions are associated with increased OCD symptoms in these subgroups of children.

However, scores on AS subtest was consistently low across all the clusters regardless of high and low of OCD scores. Therefore, this finding indicates that poor initiation, cognitive flexibility and self-monitoring abilities are not risk for OCD symptoms.

Further examination of the remaining cluster profiles indicated that the DF subtest appears to make a stronger contribution in distinguishing between the clusters than AS subtest.

For example, cluster two (n=5) and three (n=6) had very similar AS subtest scores, yet substantially different PCHOCI scores and these clusters could best be differentiated on the basis of the DF subtest score.

Cluster six (n=7) is the largest cluster and children in this cluster are among the lowest OCD symptom group. This cluster also represented by children who have better initiation and productivity as well as cognitive flexibility.

6.4 Discussion

In this study, exploration of the relationship between EF subtypes and anxiety was undertaken in order to examine whether there are any subgroups of children could be identified based on their EF functioning and anxiety profiles which may facilitate further understanding about the neuropsychological correlates underlying anxiety issues in children with ASD. Given the significant relationship between of OCD and ASD and between OCD and specific EDF areas, we are also interested to examine the relationship between difficulties in particular EF tasks and OCD characteristics in children with ASD.

Results of the cluster analysis identified eight clusters of children showing varying profiles in relation to anxiety and specific EF difficulties. 16 children showed higher levels of anxiety. These subgroups of children are also characterized by low EF subtest scores especially on the AS subtest, however this subtest was consistently low on all the clusters, perhaps indicating it is not particularly associated with anxiety. These findings were replicated in the child rated anxiety analysis.

The findings suggest that difficulties in specific EF abilities do not consistently discriminate between children with heightened anxiety and those without. Our findings therefore do not support the studies that suggest poor executive

functioning is associated with high anxiety in children and adolescents with ASD (Hollock et al. 2014). The above findings also contradict with the Attentional Control theory (Eysenck et al., 2007), which suggests that anxiety disrupts the balance in the top-down attentional control system and bottom-up stimulus-driven attentional systems and this theory also suggests that anxiety impairs the efficiency of two executive functions; the inhibition and shifting functions (Eysenck and Derakshan 2011).

6.4.1 Relationship between EF subtests and OCD

The relationship between EF subtests and OCD symptoms was also explored in this group of children. Results of the cluster analysis demonstrated that the presence of OCD symptoms are perhaps most characterized by low DF subtest scores. This indicates that impairment in initiation and productivity as well as poor cognitive flexibility may contribute to heightened OCD symptoms in children with ASD (Korkman et al., 2007).

Children with autism have been found to have difficulties generating novel ideas and responses spontaneously (Turner, 1997). The DF subtest was designed to assess behavioral productivity and the child's ability to generate unique designs by connecting up to five dots, presented in two arrays: structured and random (*ibid)*. Poor performance in this subtest indicates difficulties in the generation of novel designs and nonverbal fluency, which suggest generativity problems as a whole. Generativity has been regarded as one of the hallmark of EF dysfunctions in autism (Hill, 2004).

Our findings also indicate that the AS subtest was consistently poor across the clusters, which indicates that poor initiation, cognitive flexibility and self-monitoring are a feature of our sample.

These findings support Korkman et al. (2007) who found that children with autism frequently do very poorly on AS and DF subtests which suggests cognitive flexibility is the core EDF area for this disorder *(ibid*). Cognitive flexibility has been used interchangeably with 'set shifting' and 'mental flexibility' in executive function and often characterized by perseverative, stereotyped behaviour and difficulties in the regulation and modulation of motor acts (Hill, 2004).

Previous studies shows mixed findings in terms of relationship between specific EDF and OCD. Zandt et al. (2009) found that children with ASD perform poorly on tasks requiring generation of multiple responses, while children with OCD tended to demonstrate impairments on a task requiring inhibition and in another study deficits in organizational strategies were found to highly correlate with OCD (Greisberg & McKay, 2003). In our study, we have found that cognitive flexibility is a frequent difficulties in this subgroup of children which is consistent with
Ozonoff et al. (1994), who have found that autistic sample was significantly impaired on a measure of cognitive flexibility, and also perseveration (Liss et al., 2001).

The findings of this study also support the findings from MacKinlay et al. (2006) who found that children with ASD were less efficient at multitasking tasks, whereby they attempted fewer tasks, switched inflexibly between tasks and broke performance rules more frequently than controls. Moreover, some research has suggested that children with autism experience a sort of 'stuck-in-set' perseveration that is specific to the disorder, rather than a more global perseveration tendency (e. g. Hughes et al., 1994).

Therefore, the findings of these studies and the current study suggests EF deficits which may explain why children with ASD often experience difficulties organizing goal-directed actions in their day-to-day lives and require more support to schedule their daily activities.

6.4.2 Strengths, Limitations and Directions for future work

Among the limitations of this study is sample size. The sample size is small but is comparable with other studies that have adopted the same research framework. Autism is a lifelong developmental disorder, but paradoxically most studies of the disorder are cross-sectional. This study has adopted a cross-sectional research design also, which provides only a snapshot of what features look like at a single point in time. In addition the measures used (The NEPSY, CHOCI-R and SCAS) were not designed for children with autism. They were developed with typically developing children.

As the CHOCI-R, we have attempted to address this issue by conducting the semantic evaluation of the scale and used only the items that would be more likely to be characteristic of OCD in this ASD sample.

For the NEPSY, there are interpretation guidelines provided for use with children with autism that we have followed. On the SCAS, a recent systematic review of the properties of tools used to measure outcomes in anxiety intervention studies for children with ASD found that it is a robust measure for anxiety in children with ASD (Wigham and McConachie, 2014).

6.4.3 Directions of future work

Future work should look into conducting studies in a bigger sample whilst maintaining a focus on heterogeneity. Studies could also focus more on the less able children with ASD to ensure all points in the spectrum are represented. Furthermore multiple sources of data including combinations of test batteries, questionnaires and neurophysiological methods will further enhance our understanding of the neuropsychological correlates of anxiety in ASD.

In terms of measures for executive functions and more specifically, cognitive flexibility measures, experimental measures must evolve to reflect mechanistic models of flexibility deficits. This is because previous studies found that there is a

large gap between the day-to-day behavioral flexibility and that measured with the presently available cognitive flexibility tasks (Geurts et al., 2009). Therefore, in order to advance the field, ecologically valid measures are required to be able to resolve the paradox between cognitive and behavioral inflexibility. In the future also, it is critical to investigate how widespread a stuck-in-set perseveration may be within the subgroups of children with ASD.

Future research also should take a longitudinal approach as autism is a permanent condition and lasts throughout the lifetime of the individual. Symptoms may change, particularly in response to effective training programmes, and persons with autism may show dramatic improvement in some behaviours, therefore periodic reevaluations are necessary to respond to the changing needs of the person with autism.

6.5 Conclusion

This study was attempted to explore the association between difficulties in particular EF tasks the presence of anxiety. Given the significant relationship between of OCD and ASD and between OCD and specific EDF areas, we were also interested to examine the relationship between difficulties in particular EF tasks and OCD characteristics in children with ASD. The result of the cluster analyses indicate that there is no clear relationship between anxiety and specific EF subtests. In terms of relationship between EDF and OCD, the presence of OCD symptoms in these subgroups of children are perhaps most characterized by low DF subtest scores. Children in this study also performed poorly on AS subtest and this finding is consistently found in all clusters. This further suggests that poor initiation, cognitive flexibility and self-monitoring is a coincidental difficulties that occurs in this subgroup of children. Difficulties in these two subtests suggest problems in ‘flexibility’ and ‘generativity’ functions in EDF. Therefore, it can be concluded that the heightened OCD symptoms in this subgroups of children with ASD is characterized by inability to generating novel ideas and responses (generativity issue) as well as of ‘stuck-in-set’ perseveration (flexibility issue) .

Chapter 7. The Influence of Executive Dysfunctions and Restricted, Repetitive Behaviours (RRB) on Anxiety in ASD

7.1. Aims of Study

The primary aim of this study is to examine the relationships between parental reports of executive functioning, anxiety and restricted and repetitive behaviours in young people with ASD. Given the significant relationship between of OCD and ASD, and between OCD, EF and RRB, particular focus will be given to OCD.

7.2 Hypotheses

It is hypothesized that there will be a relationship between with executive dysfunction and repetitive behaviour and executive dysfunction and anxiety. It is also predicted that there will be a relationship between OCD, EF and RRB

Therefore, the specific hypotheses are as follow:

11. There will be a significant positive association between Executive dysfunction scores on the BRIEF and total RBQ score.
12. There will be a significant positive correlation between total anxiety score on the SCAS-P and total score on the BRIEF
13. There will be a significant positive correlation between total anxiety score in the SCAS-P and total score on the RBQ and both RBQ subscales
14. There will be is a significant positive correlation between scores on the OCD sub-scale of the SCAS-P and the set shifting scale of the BRIEF
15. There will be a significant positive correlation between the OCD subscale of the SCAS-P and total score on the RBQ and the IS subscale of the RBQ

7.3 Methodology

7.3.1 Design

A cross sectional design is used for the main part of this study. The parents who had participated in the first study were contacted and invited to participate in the current study.

7.3.2 Participants

The 36 parents of young people with ASD who took part in the earlier study were contacted and invited to participate in this study. 22 parents consented and took part in this study. A demographic questionnaire was sent out to parents in order to gather additional information about important life events, anxiety diagnosis, treatment and interventions. All the families reported that there is no significant major life events or any additional information with regard to anxiety diagnosis, treatment and interventions since their first participation in this study.

c. Comparisons of respondents and non-respondents in terms of age, autism severity and anxiety symptoms

In order to determine whether there were any differences between those who consented to take part in this second study (named the respondents) and those who did not (non-respondents) independent t-tests were performed comparing age, autism severity and anxiety symptoms measured at time one between study two respondents and non-respondents.

Age

In terms of age, the respondents group (n=22 had a mean age of 10.92 (sd= 3.03) and the non-respondents group (n=14) had an average age of 11.82, (sd=2.67). The assumption of homogeneity of variances was tested and satisfied were associated with a statistically via Levene's F test, F (34) = .245, p= .624. The independent sample t-test indicated no significant difference in age between the groups (t (34) = -. 911, p= .368) Cohen's *d* was estimated at -0.315, effect-size *r*= -0.156.

Autism severity

The respondents group (n=21) had a mean SRS score of m= 112.43 (sd= 30.87) and the non-respondents group (n=11) had mean SRS score of m= 99.45 (sd= 30.36). The Levene's F test was tested and satisfied F (30) = .056, p= .814). The independent sample t-test resulted in a non-significant difference, t (30) = 1.135, p= .265, Cohen's *d* was estimated at 0.424, effect-size *r*= 0.207.

Anxiety symptoms

The mean total SCAS score for the respondents group (N= 22) was m= 33.59 (sd= 17.45) and the non-respondents (n=12) group had a mean total SCAS score of m= 31.92 (sd= 17.68). The assumption of homogeneity of variances (Levene's F test) was tested and satisfied F (32) = .034, p= .855). The independent sample t-test indicated a non-significant difference, t (32) = .266, p= .792, Cohen's *d* was estimated at 0.095, effect-size *r*= 0.047.

In summary, the above results indicate that there were no-statistically significant differences between responders and non-responders in terms of age, autism severity and anxiety symptoms.

7.3.3 Recruitment

In this second phase, parents of the 36 participants who took part in part one were re-contacted. No further contact with the children was made. Information sheet and consent form were sent postally together with the questionnaires pack. Kindly refer to **appendix K** and **L.**

a. Inclusion and exclusion criteria*:*

All parents of children in the previous study were invited to participate. Inclusion criteria are therefore:

1. Participation in the earlier study
2. Being a parent of a child with a diagnosis of ASD

7.3.5 Procedure

A study pack consisting of a cover letter to participants, an information sheet, a consent form, all questionnaires measures and a stamped addressed envelope was sent postally to all parents. Parents who have not returned the questionnaires in one month were reminded via email. Parents were given the opportunity to ask about the research as all the contact details were provided in

the information sheets and cover letter. Ethical approval was provided by Newcastle University Ethics Committee. Kindly refer to **Appendix J**.

7.4 Results

Of the thirty-six participants invited to take part twenty two consented and provided data, three had relocated since study one and were not contactable. The remaining eleven did not respond.

7.4.1 Data screening

a. Missing Data

There is one missing item for 1 participant on the BRIEF questionnaire. Management of the missing data was handled according to the measure manual whereby a score of 1 was assigned to the item (Gioia et al., 2000; page, 7).

b. Outliers

Visual inspections of stem and leaf plots detected one outlier on the BRIEF. Guidelines on dealing with outliers in small samples by Guttmann & Smith (1969) was followed. The data was left as it is. There was no outliers on other questionnaires measures (parental report SCAS, BRIEF and RBQ).

c. Normality

Since the sample is less than 30, the distribution of scores on each measures were examined using Shapiro-Wilk test in order to determine whether the data met the assumptions of normality required for parametric testing. All variables used in this analysis met the assumptions.

7.4.2 Internal Consistency of questionnaires measure

Reliability tests (Cronbach's alpha) were carried out on all of the questionnaires measures. (See table 7.1).

Table 7.1

Participant descriptive statistics on all measures

	Mean	SD	Range	Cronbach's alpha
Parent Rated SCAS total score – study 1	33.59	17.45	1 - 68	**.901**
Parent Rated SCAS total score – study 2	30.50	14.60	5 - 63	**.888**
BRIEF total score	159.50	30.31	87 - 209	**.974**
RBQ total score	18.32	9.95	3 - 34	**.881**

Key: SCAS – The Spence Children's Anxiety Scale; BRIEF – Behaviour Rating Inventory of Executive Function; RBQ – Repetitive Behaviour Questionnaire.

According to Field (2005), a Cronbachs alpha of at least 0.7 indicates good reliability. In this study, all questionnaires measures achieved a Cronbach's alpha >.7 which demonstrated good internal consistency. The BRIEF total score demonstrated excellent internal consistency (Cronbach's alpha .978). Therefore, all of the questionnaires measures used in this study can be reported to have good levels of reliability (Field, 2005).

7.4.3 Descriptive Statistics

a. Anxiety-Spence Childhood Anxiety Scale – Parent version (SCAS-P) for study 2

In study 1, anxiety was assessed by the Spence Childhood Anxiety Scale (SCAS) completed by both the parent and the children. However, in this second stage only

parent rated SCAS was used. A higher score indicates more elevated anxiety symptoms. Table 7.2 shows the profile scores for the SCAS-P in study and 2.

Table 7.2

Spence Childhood Anxiety Scale (SCAS)-Parent version (study 2)

SCAS-Parent Subscale, N=22	Mean (SD)	Range
Separation Anxiety	5.59 (4.27)	0-13
Social Phobia	6.91 (4.96)	0-18
Obsessive Compulsive	4.41 (3.28)	0-11
Panic/agoraphobia	4.41 (3.65)	0-17
Physical Injury Fears	4.88 (3.13)	0-11
Generalized anxiety	5.71	0-12
Total	33.00	1-68

b. Behaviour Rating Inventory of Executive Function (BRIEF)

The parent version of BRIEF was administered in this study to obtain information on daily EF behaviours. Table 7.3 below shows the BRIEF profile subtest scores for this study.

Table 7.3

BRIEF Profile Subtests Scores

BRIEF Subtests N=22	Mean	SD	Range
Inhibit	20.82	5.51	10–30
Shift	18.18	3.81	9–24
Emotional Control	21.18	5.32	11–30
Initiate	17.00	4.16	9–24
Working Memory	22.68	5.74	10–30
Plan/organize	26.45	5.24	15–36
Organization of Materials	14.09	3.35	6–18
Monitor	19.09	2.58	13–23
Total	**159.50**	**30.31**	**87 - 209**

c. Repetitive Behaviour Questionnaires (RBQ)

In the RBQ, the parent records the behaviour that their son or daughter shows over the last three months and rate the most usual way he/she displays these behaviours. The following table shows RBQ total and subtest scores.

Table 7.4

RBQ Profile Subtests Scores

RBQ Subtests N=22	Mean	SD	Range
Sensory/Motor behaviours	7.09	5.57	0-18
Insistence on sameness/ circumscribed interests	11.23	5.28	0-21
Total	**18.32**	**9.95**	**0 -39**

7.4.4 Statistical analysis

7.4.4.1 Overview

The main aims of the study were to determine whether there was a relationship between parental reports of executive functioning, anxiety and restricted and repetitive behaviours in young people with ASD. The relationships between OCD, EF and RRB were examined also, due to the significant relationship between of OCD and ASD reported in the literature. Changes in anxiety profiles over timewere explored in terms of the relationship between first study and second study, but are reported elsewhere (see chapter 8). A series of correlational analyses were used to test the hypotheses. Descriptive statistics were calculated also for the questionnaire measures. Data analyses were completed using SPSS version 21.0. The following sections will inform the result of the statistical analyses in this study.

7.4.4.2 Results for Main hypothesis

A correlational analysis using a single correlational matrix was conducted to explore the main hypothesis as well as exploratory hypothesis. The following table (Table 7.5) shows the relationship between all the variables of interest:

Table 7.5

Correlations between SCAS-P (study 2-total and OCD subscale score), RBQ (total and subscale score) and BRIEF (total and subscale score)-(N=22)

Variables	SCAS-P (total score)	SCAS-P (OCD)	BRIEF (total score)	BRIEF-Inhibition (total score)	BRIEF-Set-shifting (total score)	BRIEF-Initiation (total score)	RBQ (total score)	RBQ-RSM (total score)	RBQ-IS (total score)
SCAS-P (total score)	-								
SCAS-P (OCD)	.713** .000	-							
BRIEF (total score)	.631** .002	.410 .058	-						
BRIEF-Inhibition (total score)	.568** .006	.299 .177	.920** .000	-					
BRIEF-Set-shifting (total score)	.759** .000	.513* .015	.867** .000	.831** .000	-				
BRIEF-Initiation (total score)	.450* .035	.392 .071	.855** .000	.739** .000	.678** .001	-			
RBQ (total score)	.540** .010	.469* .028	.424* .049	.369 .091	.493* .020	.569** .006	-		
RBQ-RSM (total score)	.352 .108	.315 .153	.329 .134	.222 .320	.342 .119	.540** .009	.921** .000	-	
RBQ-IS (total score)	.645** .001	.551** .008	.451* .035	.461* .031	.568** .006	.502* .017	.912** .000	.681** .000	-

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

a. There will be a significant positive association between Executive dysfunction scores on the BRIEF and total RBQ score.

A Significant correlation was found between the total score of the BRIEF and the total score of RBQ (r=.424, p= .049).Therefore, the prediction was supported.

b. There will be a significant positive correlation between total anxiety score on the SCAS-P and total score on the BRIEF

It is predicted that there will be a significant relationship between anxiety and executive dysfunction. In order to ascertain this relationship the total anxiety score of the SCAS-P was analyzed together with the total score on the BRIEF.

A Significant correlation was found between parent rated anxiety and the total score of the RBQ (r = .540, p = .010). Therefore, the prediction was supported.

c. There will be a significant positive correlation between total anxiety score in the SCAS-P and total score on the RBQ and both RBQ subscales

The above findings indicate that the IS subscale of the RBQ and the total score of the SCAS-P were significantly correlated (r=.645, p=.001). Similarly the RBQ total score was also correlated with total score of SCAS-P (r= .540, p=.010). On the other hand the result shows that there is no significant association between RSM subscale and the SCAS-P.

d. There will be is a significant positive correlation between scores on the OCD sub-scale of the SCAS-P and set shifting scale of the BRIEF

A significant correlation was found between the OCD subscale of the SCAS-P and the set-shifting subscale of the BRIEF (r = .513, p= .015). Therefore, the prediction was supported.

e. There would be a significant positive correlation between the OCD subscale of the SCAS-P and total score on the RBQ and the IS subscale of the RBQ

A significant correlation was found between scores on the IS subscale of the RBQ and the OCD subscale of parent rated anxiety score (r = .551, p = .008). No significant correlation found between scores on the RSM subscale and OCD subscale. In addition, a significant correlation was found between RBQ total score and the OCD subscale (r = .469, p = .028).

7.4.4.3 Exploratory Hypothesis

a. There would be a significant positive relationship between the set-shifting subscale of the BRIEF and total score of RBQ.

Result shows a significant correlation between the set-shifting subscale of the BRIEF and RBQ total score (p= .493, r= .020). Therefore, the prediction was supported.

b. There will be a significant positive relationship between set-shifting subscale of the BRIEF and RSM subscale of RBQ.

In this level of exploratory analysis, the association of set-shifting subscale and both of the RBQ subscales was explored.

Results indicates there is a positive correlation (p>0.01) between set-shifting and IS subscale of RBQ (r = .568, p = .006) but not the RSM subscale. Therefore, the prediction is unsupported.

c. There will be a significant positive correlation between Inhibition subscale of the BRIEF and the total RBQ score.

It is predicted that there will be a significant positive correlation between the inhibition subscale of the BRIEF (a measure of response inhibition) and total RBQ score. Results indicate no significant correlation between the inhibition subscale and also RBQ total score. Therefore, the prediction was unsupported.

d. There will be a significant positive correlation between Initiation subscale of the BRIEF and both of the RBQ subscales.

The analysis was run between the total score of Initiation subscale of the BRIEF and both of the RBQ subscales. This is to determine whether the association is being held at any of the subscale or with both of the RBQ subscale. It is hypothesized that there will be a significant positive correlation between Initiation subscale of the BRIEF and both of the RBQ subscales. Result shows that there is are significant correlations (p>0.05) between the initiation subscale and both the IS subscale of the RBQ (p= .502, r= .017) and the RSM subscale of RBQ. Therefore, the prediction was supported.

e. There will be a significant positive correlation between emotional monitoring of the BRIEF and total score of SCAS-P.

A Significant correlation (p>0.01) was found between emotional monitoring subscale of the BRIEF and also parent rated anxiety on study 2 (p= .638, r= .001). Therefore, the prediction was supported.

7.5 Discussion

7.5.1 Overview

This study aimed to determine whether there was a relationship between parental reports of executive functioning, anxiety and restricted and repetitive behaviours in children with ASD. Parents from the first study were invited to join this study and 22 parents participated.

7.5.2 The Relationship between EF, RRB and anxiety

Research on anxiety and neuropsychological functioning suggests that ASD children demonstrate impairments on a tasks requiring inhibition (Zandt et al., 2009) and deficits in organizational strategies (Greisberg & McKay, 2003). In a more recent study, Hollocks et al. (2013) found that executive dysfunctions are associated with anxiety. All these studies utilized test batteries based on direct testing. In our earlier study, we found no association between EF and anxiety on a performance-based measure on EF test battery (The NEPSY-II; Korkman et al, 2000). However it could be argued that the measure used was lacking in term of ecological validity and real world impact of executive deficits as this is a laboratory based test. Therefore, in this follow up study parent reports of everyday executive function deficits were explored using the BRIEF (Gerard et al. 2000) leading to the findings that parent reports of EF dysfunctions are associated with heightened anxiety in children with ASD. This is among the first study to find this relationship utilizing parent report of everyday EF.

Zandt et al. (2007) indicates that OCD is one of the commonest types of anxiety in ASD and they also found that children with OCD engaged in more repetitive behaviour focussed around routines and rituals. Based on parent reports we also found children with ASD with high OCD scores also engaged in more repetitive behaviours. Further analysis on specific RRB, revealed that children with high

levels of insistence on sameness behaviours were had higher OCD scores. These findings support and build on the findings of the study Rodgers et al. (2012b), who found that children with higher anxiety had more repetitive behaviours and higher levels of insistence on sameness were associated with more anxiety.

Greisberg and McKay (2003) examined neuropsychological features of obsessive-compulsive disorder (OCD) and findings of this study point towards deficits in organizational strategies, suggesting problems in executive functioning. Consistently, we have found that set-shifting is associated with OCD symptoms. Our findings also builds on Mackinlay et al. (2006), who found that children with ASD were less efficient at planning, attempted fewer tasks, switched inflexibly between tasks and broke performance rules. Similarly, Thede and Coolidge (2007) found that children with HFA and Asperger have deficits in EF and the Asperger group also had higher scores on OCD scales.

Further exploratory analysis on the relationship between emotional monitoring and anxiety, indicates that lack of emotional monitoring is associated with high anxiety supporting findings by Leekam (2011). In addition, Zingerevich and Patricia (2009) found that executive dysfunctions contribute to difficulties participating in school activities, particularly the abilities to resist impulsive responses, to stop a behaviour at the appropriate time and to regulate emotional responses. These difficulties with emotional regulation are also associated with heightened RRB. This could explain why students with ASD often struggle to maintain their attention and regulate their emotions and behaviours in mainstream classrooms, despite receiving a range of specialist support services in the classroom (Ashburner et al., 2010).

7.5.3 Relationship between EF and RRB

The literature shows some support for a relationship between EF and repetitive behaviour in children with ASD (Turner 1997, 1999). Turner and Russell (1997) found that perseveration on a set-shifting task was correlated with more primitive stereotyped behaviours such as hand flapping while impoverished generativity was

correlated with higher level repetitive behaviours such as circumscribed interest. We have also found that executive function difficulties are associated with higher levels of RRB, which further supports the findings of previous studies by Turner and Russell (1997).

Several areas of EF are related to RRB such as cognitive flexibility (Lopez et al. 2005) set-shifting and generativity (Turner and Russell, 1997) poor regulation and control (Leekam et al., 2011). We have found that set-shifting deficits are associated with RRB, especially the insistence of sameness and not with the repetitive motor behaviour. This is inconsistent with the with the findings by Turner and Russell (1997) who have found that set-shifting was correlated with more primitive stereotyped behaviour such as hand flapping. The findings suggest that set shifting deficits may be associated with the insistence of sameness which characterized by compulsive adherence to routine, and stereotyped, repetitive behaviours (Turner, 1995). These difficulties in turn might make it hard for ASD children to adjust to the dynamic demands of their environment. Their preference for sameness is typically accompanied also by considerable distress when preferred behavioural patterns are interrupted.

Further exploratory investigation on the relationship between specific EF deficits and RRB indicates that deficits in inhibition are not so associated with RRB. This is contradict with the findings by Lopez et al. (2005) who have found that response inhibition difficulties were highly related to RRB.

The final EF function that has been investigated is difficulty in initiation. We have found that children with ASD who have difficulty in initiation, present with more restricted and repetitive behaviours. This finding supports Loftin et al. (2007) who have found that students with autism who have difficulty initiating social interactions exhibit more RRB.

7.6 Strengths and limitations

In this study, we have presented data from a group of children with confirmed diagnosis of ASD utilizing a well-validated (in TD) measures in anxiety, EF. To date, this is one of the first studies to have explored the neuropsychological

correlates of anxiety together with the core symptoms of ASD (RRB) and explore the interplay in the relationship between these three variables. Wood and Gadow (2010) suggested that anxiety may play at least three roles: (a) a downstream consequence of ASD symptoms; (b) a moderator of ASD symptoms severity; and as a proxy of core ASD symptoms. This study also among the very few studies that have found relationship between EF and RRB.

Despite these strengths, there are several limitations that restrict the interpretation of our findings. First, the sampling technique that has been adopted may be prone to bias and limit generalization of the findings. Postal questionnaire methods are inflexible because there is usually no opportunity to probe or observe the social context in which questions are answered. In addition, the BRIEF and SCAS-P questionnaires have not been validated for children with ASD. Some parents also may not have insight into some aspects of emotional functioning of their children. However, these have been balanced against the choice of questionnaires which are closed-ended questions, straightforward, participants-friendly, without compromising their validity and reliability. Even though the BRIEF and SCAS-P was not validated among children with ASD, these measures have been commonly used in ASD research.

The second limitation that should be taken into account is that our data are based on parent-report measures only, which possibly causes inflated associations between the variables under study because of a shared method variance. The final limitation of this study concerns the cross-sectional research design, which only allows for ascertaining associations between anxiety, EF and RRB. Therefore, one cannot assume that EF and RRB directly cause anxiety issues in children with ASD. To confirm that these relationships have a causal nature, more longitudinal research investigating changes of these variables over time are needed.

7.7 Practical Implications and suggestions for future study

Like previous research we have found that parents of children with ASD report that their children have difficulty in shifting their attention from one task to another and organizing goal-directed action in their daily lives. This suggests that support may be required in order to schedule daily activities and break difficult tasks into a more manageable tasks. It is essentials that parents and teachers are well-informed about these difficulties, so that better mutual relationship and cooperation can be expected.

We also support other research that suggests that children with ASD find it difficult to maintain and regulate their emotions as well as to maintain peer relationships. Therefore, interventions focusing on the development of emotion regulation skills are essential and methods encompassing the management of impulsivity, relaxation techniques as well as role play in initiating and maintaining peer relationship will be off great value.

We found associations between RRB, EF deficits and RRB. Leekam et al. (2011) suggests that it is likely neurocognitive functioning difficulties in ASD is a consequence rather that a cause of RRB. Since this study is a cross-sectional in nature and cannot infer causality, future studies should adopt a longitudinal study and investigate changes over time in these relationships. This will allow further examination whether the behavioural aspects of autism are both affected by and also affect neurocognitive development (*ibid*).

Future studies should also should focus on assessing a wide range of different EF functions (Hill, 2004) using more ecologically valid real world measures. The combinations of physiological methods, neuropsychological batteries, questionnaires measure as well as behavioural observation at home or classroom settings will enhance the understanding of day to day anxiety, RRB and EF difficulties as well as the interplay of these with core difficulties of ASD.

Further investigation in a larger sample size also is needed to enable further specification of the associations between specific EF deficits and specific anxiety types and RRB subtypes.

7.8 Conclusion

This study aimed to examine the relationships between parental reports of executive functioning, anxiety and restricted and repetitive behaviours in children with ASD. 22 parents participated in this cross-sectional, postal study. Data was analysed using correlational analyses. Primary findings indicate that everyday EF deficits were associated with heightened anxiety. Emotional monitoring deficits were associated with anxiety, with set-shifting difficulties and higher level of sameness (RRB) associated specifically with higher OCD scores. Further exploration of the relationship between EF and RRB indicated that executive function difficulties were associated with higher levels of RRB. In addition, deficits in inhibition were associated with RRB and specifically set-shifting deficits were associated with insistence of sameness (RRB). Finally, we found that children with ASD who have difficulty in initiation present with more restricted and repetitive behaviours. The strengths, limitations, practical implications and suggestions for future study was also discussed in line with the findings and previous literature findings.

Chapter 8. Comparison of Anxiety among Children with ASD over Time

8.1 Introduction

Autism is a life-long condition. Symptoms may change, particularly in response to effective training programmes, and people with autism may show dramatic improvement in some behaviours. Paradoxically most studies of the disorder are cross-sectional. Cross-sectional studies provide only a 'snapshot' of the outcome and the characteristics associated with it, at a specific point in time (Levin, 2006). Research should take into account an individual's developmental trajectory, which is essential for understanding the disorder. Because symptoms may change, periodic re-evaluation is necessary to respond to the changing needs of the person with autism.

There is a small body of research that has explored anxiety changes among children with ASD over time. . Most of the available studies are looking at the changes of anxiety before and after intervention was implemented (e.g. Reaven et al., 2009 & Chalfant et al., 2007). There is one study by Green et al. (2012) which have explored the emergence of and bidirectional effects between anxiety and sensory over-responsivity (SOR) in a young children (toddlers) with ASD. In this study, 149 toddlers with ASD and their mothers were assessed at 2 annual time points. Results indicate that anxiety symptoms increased over time while SOR remained relatively stable. Results also suggest that SOR emerges earlier than anxiety, and predicts later development of anxiety.

Changes in anxiety overtime are better understood among typically developing (TD) children. For example, Last et al. (1996) evaluated course and outcome of DSM-III-R anxiety disorders prospectively in clinically referred children. Children were blindly and repeatedly assessed with a structured diagnostic interview over a 3- to 4-year period. Both psychopathological (attention-deficit hyperactivity disorder, n = 50) and never psychiatrically ill (NPI, n = 83) controls served as comparison groups for children with anxiety disorders (n = 84). The majority of children (82%) were free from their intake anxiety disorders by the end of the

follow-up. Relapse of these anxiety disorders after remission was rare (8%). During follow-up, anxious children were more likely to develop new psychiatric disorders (30%), primarily new anxiety disorders (16%), than were NPI children (11% and 2%, respectively), but not psychopathological controls (42% and 10%, respectively). Results also suggested a favourable outcome with respect to diagnostic status for clinically referred children with anxiety disorders. However, these children may be at risk for new psychiatric disorders over time.

In addition, Cole et al. (1998) examined elementary school students (n = 330) and their parents (n = 228), in a 3-year longitudinal study of the temporal relation between anxiety and depressive symptoms in children. Every 6 months, children and parents completed depression and anxiety questionnaires for a total of 6 waves. Structural equation modelling revealed that individual differences on all measures were remarkably stable over time. Nevertheless, high levels of anxiety symptoms at 1 point in time predicted high levels of depressive symptoms at subsequent points in time even after controlling for prior levels of depression symptoms. These findings were consistent across self- and parent reports.

Finally, Costello et al. (2003) conducted a longitudinal community study in a sample of 1420 children, assessing the prevalence and development of psychiatric disorders annually from age 9 through to 16 years. Results indicated that social anxiety, panic, depression, and substance abuse increased in prevalence, whereas others, including separation anxiety disorder and attention-deficit/hyperactivity disorder (ADHD), decreased. Lagged analyses showed that children with a history of psychiatric disorder were 3 times more likely, than those with no previous disorder, to have a diagnosis at any subsequent wave. Continuity of the same disorder (homotypic) was significant for all disorders except specific phobias. Continuity from one diagnosis to another (heterotypic) was significant from depression to anxiety and anxiety to depression, from ADHD to oppositional defiant disorder, and from anxiety and conduct disorder to substance abuse.

As a summary, the literature shows that anxiety symptoms among children with ASD, tend to increase over time (Green et al., 2012). In TD children, there is mixed evidence in terms of anxiety changes over time. Some studies show reduction in anxiety rates (e.g. Last et al., 1996), while others are increased (e.g. Costello et al., 2003) and the rest are stable over time (Cole et al., 1998). In terms of specific anxiety subtypes, social anxiety and panic tend to increase, whilst separation anxiety decreases over time in TD children. However, there is no study available in terms of the changes in specific anxiety subtypes among ASD children over time.

8.1.1 Limitations of current findings

To date, there are only a few studies that have been undertaken which have explored changes in anxiety over time among children with ASD. There is an indication that increasing age is associated with developmental changes in anxiety. Mayes et al. (2011) found that anxiety and depression were higher in older children with in ASD. Therefore, further research is needed in order to understand how anxiety may change over the course of childhood (*ibid*).

So far, we know about how anxiety profiles may change over time in typically developing children, but there is still an absence of information on children with ASD. In terms of specific anxiety subtypes that may change over time in ASD also, there are no studies available which specifically looked into this area. Specific phobias were found to be more common in younger TD children, whereby OCD and social phobia become more common in adolescents (Ollendick et al., 2004). In their comprehensive review of anxiety in children with ASD, White et al. (2009) found that simple phobias, generalized anxiety disorder, separation anxiety, OCD and social phobia are the most commonly reported anxiety disorders in children with ASD. However, the developmental waxing and waning of specific forms of anxiety is not well understood (*ibid*).

In our earlier studies, we explored the correlates of anxiety in ASD and then explored heterogeneity in ASD using cluster analytic techniques and have identified

sub-groups of participants that represent substantial amounts of variability in symptom profiles in terms of their anxiety, EF and sensory processing dysfunctions. This work was cross-sectional in nature and there remains a need to explore further any potential changes in anxiety over time.

8.1.2 Aims

Changes in parent reports of anxiety over time were explored for a subgroup of the young people with autism, who also took part in studies reported earlier in this thesis. Therefore, the aim of this study is to compare the changes in anxiety profiles at study 1 and study 2.

8.1.3 Hypothesis

It is hypothesized that there will be significantly higher anxiety symptoms at time 2 (second study) compared to time 1 (first study).

It is also hypothesized that there will be significantly higher anxiety scores at time 2 on generalized anxiety disorder, separation anxiety, OCD and social phobia subscale.

8.2. Methodology

8.2.1 Design

This study examined changes in anxiety over time whereby anxiety scores at study 1 were compared with anxiety score at study 2. The parents who had participated in the first study were re-contacted and invited to participate in the current study.

8.2.2 Participants

22 parents consented and took part in this study. This study is part of the larger study about the relationship between anxiety, executive dysfunctions and repetitive behaviour. A demographic questionnaire was sent out to parents in order to gather

additional information about important life events, anxiety diagnosis, treatment and interventions. All the families reported that there is no significant major life events or any additional information with regard to anxiety diagnosis, treatment and interventions since their first participation in this study. The mean follow-up time for the 22 participants from study 1 to study 2 was 21 months (range = 20-30 months). There were no- significant differences between respondents and non-respondents in terms of age (t (34) = -. 494, p= .625), autism severity (t (30) = .619, p= .541) and anxiety symptoms (t (32) = -.020, p= .984). Kindly refer to Chapter 7 for details of this analysis.

8.2.3 Recruitment

Recruitment for this this study is the same as study 2. Kindly refer to Chapter 7.

8.2.4 Inclusion and exclusion criteria*:*

The inclusion and exclusion criteria for all participants in this study are the same as participants in study 2. Kindly refer to chapter 7.

8.2.5 Measures

a. The Spence Children's Anxiety Scale-SCAS (Spence, 1998)

The parent rated version was administered. This measure was completed by all participants at the earlier testing phase and was re-administered to the parents in this second phase of study. Kindly refer to chapter 4 for detail descriptions of this measure.

8.3 Results

8.3.1 Comparison of anxiety score between time 1 (first study) and time 2 (second study).

Anxiety scores at two time points were examined for all participants. It was predicted that there would be a significantly higher total anxiety scores at time 2 (second study) than the time 1 (first study). The total score of parent rated SCAS of study 1 and the total score of parent rated SCAS of study 2 were subjected to paired t-tests in order to investigate the changes in anxiety over time. The following table (table 8.1) shows the data for this analysis.

Table 8.1

Comparison of anxiety in study 1 and study 2

	Mean **Mean**	**SD** **SD**	**Std. Error Mean** **Std. Error Mean**	***r*** ***r***	***p*** ***p***	***t (df)*** ***t (df)***	***p*** ***p***	***Cohen'*** ***Cohen'***
SCAS (study 1)	33.59	17.45	3.72	.641	.001	1.049 (21)	.306	0.129
SCAS (study 2)	30.50	14.61	3.11					

There's no-statistically significant difference between scores at the two time points.

8.3.2 Comparison of anxiety subscale score between time 1 and time 2

Specific phobias were reported as more common in younger children with ASD, whereby OCD and social phobia become more common in adolescents (Ollendick et al., 2004). Therefore, the next important step is to investigate whether specific anxiety subtype scores change over time. Each of the sub-scale scores of SCAS-P (at time 1 and time 2) was subjected to paired sample t-tests.

Table 8.2

Comparisons between separation anxiety subscale of study 1 and 2

	Mean (SD)		**Std. Error Mean**		***t* (*df*)**	***p***	***Cohen's d***
	Study 1	**Study 2**	**Study 1**	**Study 2**			
Separation anxiety	6.68 (4.70)	5.59 (4.27)	1.003	.911	1.496 (21)	.150	0.243
Social Phobia	7.00 (5.27)	7.27 (3.43)	1.124	.730	-.261 (21)	.797	-0.061
OCD	4.82 (3.61)	3.18 (2.54)	.769	.541	2.861 (21)	.009*	0.525
Panic/ Agoraphobia	4.36 (3.95)	4.45 (3.16)	.841	.673	-.140 (21)	.890	-0.025
Physical Injury	5.00 (2.71)	4.82 (3.20)	.577	.682	.370 (21)	.715	0.061
GAD	5.73 (3.28)	5.18 (2.56)	.700	.545	1.121 (21)	.275	0.187

*. Significant at p < .05.

There were no significant differences between anxiety subscales scores for any of the subscales with the exception of OCD where scores were significantly higher at time one (see table 8.2 above)

8.4 Discussion

8.4.1 Overview

This study is looking the changes in parent reports of anxiety over time for a sample of young people with ASD. Previous research shows that there is an indication that

older age is associated with higher anxiety in young people with ASD anxiety (Mayers et al., 2011). Our findings indicate that there are no significant changes in parent reported anxiety over approximately a 20 month period. This finding is inconsistent with the previous findings which indicate that anxiety is higher in older young people with ASD. For example, van Steensel et al. (2011) in their review on specific anxiety disorders in children with ASD, they found that studies that reported a higher mean age also reported higher prevalence rates of anxiety in general and also on the GAD subscale.

In terms of specific anxiety problems, previous research indicates that specific phobias are more common in younger children, whereby OCD and social phobia are more common in adolescents (Ollendick et al., 2004). In this study, we have found no significant changes over time in most of the anxiety subscales, with the exception of OCD where we found higher scores at time one. This change in OCD scores is not what we expected. It is perhaps worthy of note that at the time of the completion of study two parents were also asked to complete the RBQ. As reported earlier in the thesis there is some conceptual overlap between items considered as OCD items and RRB. It might be suggested therefore that the completion of the SCAS P OCD items proximal to the completion of the RBQ may have had a priming effect, such that items which are encapsulated within the OCD subscale have been reframed by parents as RRB items and that this is responsible for the reduction in OCD scores at time two. Indeed the conceptual overlap between some features of OCD and RRB, make differentiation challenging (Bejerot, 2007) and reliance on questionnaire measures makes the process of differentiating between RRB and anxiety challenging (Rodgers et al, 2012).

The findings here indicate that parent reported anxiety remains high over time for this group of young people but does not significantly increase further during our time period.

8.4.2 Strengths and limitations

This study is among the few studies that have been undertaken which have explored potential changes over time in anxiety among children with ASD.

There are number of limitation which needs to be considered. Firstly, the number of respondents for the study (n = 22) is small, though comparable with other studies who have used the atypical populations as their sample (e.g. Rodgers et al. 2102a & b). Secondly, the time frame between study 1 and 2 is brief as compared to other study that have used almost similar method (e.g. Green et al., 2012).

In our study, we have used parent report only which may possibly cause inflated associations between the variables under study because of a shared method variance. In addition, the sampling technique (postal questionnaires method) is inflexible because usually there is no opportunity to probe or observe the social context in which questions are answered. Furthermore, the SCAS-P questionnaire has not been validated for children with ASD. However, these have been balanced against the choice of questionnaires which are closed-ended questions, straightforward, participants-friendly, without compromising their validity and reliability. Even though the SCAS-P has not been validated among children with ASD, these measures have been commonly used in ASD research (Wigham & McConachie (2014).

8.4.3 Practical Implications and suggestions for future study

In this study, we have found that most of the anxiety subscale scores have remained high over time. Therefore, anxiety does not naturally diminish with time for children with ASD. It is recommended that children with ASD are assessed regularly in terms of their anxiety symptoms. Specific effective interventions tailored for children with ASD need to be implemented either as individual, group or family therapies. Among the proven effective interventions is CBT. For example, Lang et al. (2010) found that CBT is an effective treatment for anxiety in individuals with Asperger's. However, data involving other ASD diagnostic sub-types is limited. In addition, Sung et al. (2011) compared the effects of a 16-week

CBT program and a Social Recreational (SR) program on anxiety in children with ASD. They found that children in both programs showed significantly lower levels of generalized anxiety and total anxiety symptoms at 6-month follow-up on SCAS-C. Furthermore, Russell et al. (2013) found that both anxiety management and CBT were effective in treating comorbid OCD in young people and adults with ASD. Finally, Storch et al. (2013) found that relative to usual care, CBT adapted for anxious youth (7–11 years of age), with high-functioning ASD, demonstrates large effects in reducing anxiety symptoms.

In addition, future studies are needed with larger samples and longer time frames with participants assessed at two or more time points in order to examine the patterns of changes over time. Future research could also examine a broader age range to determine developmental trajectories more fully. We employed only parent report in this study. Of course, future research should endeavour to utilize self, parents and teachers report in order to obtain a fuller picture of anxiety changes in children with ASD over time.

8.5 Conclusion

This study aimed to compare parent reports of anxiety over time for a group of young people with ASD. 22 parents participated in this postal study. Primary findings indicate that there are no significant changes in anxiety over a 20 month timescale, with the exception of OCD which reduced over time. The strengths, limitations, practical implications and suggestions for future studies were also discussed in line with the current findings and previous literature findings.

Chapter 9: Discussion

9.1 Overview

Central to the entire study of psychiatric comorbidity of ASD is the understanding of possible factors affecting clinical presentations of anxiety in young people with ASD. Recent developments in the field of ASD have led to a renewed interest in behavioural and neuropsychological markers underlying the spectrum of autism as part of 'gold standard' approach to ASD diagnosis. One of the attempts is through exploring executive functions (EF), and sensory processing (SP), associated with anxiety. This research aimed to determine the relationships and variability amongst these constructs in order to hopefully to shed light on the nature of ASD related anxiety.

White et al. (2009) conducted a systematic review of anxiety in children and adolescents with autism. The results of the review suggest that anxiety is indeed common in children and adolescents with ASD and may be source of additional morbidity. There is a growing body of research which has attempted to explore anxiety in children with ASD (e.g. Ghaziuddin, 2002; De Bruin et al., 2006; White et al., 2010; Van Steensel et al., 2011; Hallet et al., 2013). Relationships between SP and anxiety in children with ASD have been well-established (e.g. Pfeiffer et al., 2005; Ben-Sasson et al., 2009; Green & Ben-Sasson, 2010; Green et al., 2011). There is very little literature however that has examined the relationship between EF and anxiety (e.g. Zandt et al., 2009) and no reviews have been conducted looking at either the relationships between anxiety and EF difficulties or SP atypicalities in children with ASD. Therefore, the current reviews explored these potential relationships in detail, looking at studies which have explored the relationship between anxiety and EF and anxiety and SP in ASD.

Evidence from research investigating structural brain abnormalities in children with autism suggests that prefrontal areas do process abstract representations, but the initial formation of those representations is entirely dependent on sensory input from

the internal and external environment (e. g. Brownell et al., 2000). An autism related deficit in rapid shifting of attention has been observed during shifts between sensory modalities (Burack et al., 1997) and between spatial locations (e.g. Belmonte, 2000) suggesting a link between EF and SP. Therefore, shifting toward the investigation of more complex levels of construct including both EF and SP may help explain anxiety issues in children with ASD.

Heterogeneity in ASD in terms of its basic features has been acknowledged since the original description by Kanner (Kanner, 1946). Overall, ASD presents with broad variation in the expression of phenotypic characteristics and severity which suggests the involvement of multiple predisposing factors which interact in complex ways (Belmonte et al., 2004). Most of the research to date has focussed on describing autism as a homogenous construct. Indeed in our correlational analysis study (Chapter 3) exploring associations between anxiety, EF and SP, we also utilized a group based analysis. However, due to the heterogeneity associated with ASD the potential relationships between anxiety and other features, such as EF deficits and sensory processing atypicalities may not be detected at group level. Hence, exploring data at subgroup level is an important step forward. Therefore, in subsequent chapters we employed a cluster analytic technique in order to determine whether subgroups of children can be identified within an ASD sample based on their profiles in relation to anxiety, executive functioning and sensory atypicalities, whilst taking into account other developmental characteristics such as age, ability and ASD severity.

There are wide variations in the nature and severity of executive dysfunctions (EF) in autistic children (Geurts, Verté et al. 2004), suggesting research should consider EF as a multidimensional rather than a unitary construct in order to obtain more precision in the nature of the dysfunctions associated with autism. In this programme of work we also explored therefore the associations between specific EF subtypes and anxiety. Given the significant relationship between OCD and ASD and between OCD and specific EF areas, we were also interested to examine the relationship between particular EF tasks and OCD characteristics in children with ASD.

Turner (1997, 1999) has suggested that executive dysfunction may be responsible for the stereotyped, repetitive behaviours of Autism Spectrum Disorders. Research on Obsessive Compulsive Disorder (OCD) and RRB in children with ASD indicates that OCD is one of the commonest types of anxiety in ASD (Greisberg and McKay, 2003). Therefore, a further study was conducted which aimed to examine the relationships between parental reports of executive functioning, anxiety and restricted and repetitive behaviours in young people with ASD. Given the proposed relationship between of OCD and ASD, and between OCD, EF and RRB, particular focus was given to OCD.

In our earlier studies we explored the correlates of anxiety in ASD and then explored heterogeneity in ASD using cluster analytic techniques and have identified sub-groups of participants that illustrate the substantial amounts of variability in symptom profiles in terms of anxiety, EF and sensory processing dysfunctions within an ASD sample. This work was cross-sectional in nature and there remains a need to explore further any potential changes in anxiety over time. Thus, we explored changes in parent reports of anxiety over two points for a subgroup of the young people with ASD, who also took part in studies reported earlier in this thesis.

The following section will discuss in detail the principal findings of the systematic reviews as well as the empirical investigations. The strengths, limitations, practical implications and suggestions for future research will be discussed accordingly, which hopefully in turn will contribute towards better understanding of the nature of anxiety in children with ASD.

9.2 Principal Findings

9.2.1 Systematic reviews exploring the relationships between anxiety and EF and anxiety and SP in ASD.

The results of our systematic reviews suggest that there appears to be some emerging evidence of a link between executive dysfunction and anxiety in children with ASD, particularly with regard to cognitive inflexibility and anxiety. Zandt et al., (2009), report a specific association between EF and OCD, suggesting that this

relationship may exist in the context of specific anxiety subtypes. Even though OCD is no longer considered an anxiety disorder in DSM V, further investigation is needed to ascertain whether specific EF deficits relate to specific anxiety subtypes and whether there any potential causal relationship between them. There also appears to be evidence of a link between SP atypicalities and anxiety in children with ASD, particularly with regard to SOR and anxiety. Further investigation is also needed in order to ascertain whether specific SP atypicalities or sensory input relate to specific anxiety subtypes and whether there is any potential causal relationship between them.

9.2.2 Relationships between executive functions and sensory processing in relation to anxiety in children with ASD.

Unlike Hollock et al (2014) who suggest that there is relationship between EF and anxiety in ASD we found little evidence for this relationship in our sample. Similarly, in contrast to Zandt et al. (2009) who report a relationship between OCD and EF, our results indicate that there is no such relationship in our sample. This finding is therefore not consistent with studies which suggest that OCD is commonly associated with mild cognitive dysfunction on tasks involving executive functioning (e.g. Greisberg & McKay, 2003; Kuelz, Hohagen & Voderholzer, 2004a). Our findings also indicate that there is a relationship between Panic/Agoraphobia on the parent rated SCAS and Executive dysfunctions. This is the first study that has found this relationship in children with autism.

Using regression analyses, we explored predictors of anxiety and found that increasing age and the presence of a higher level of sensory processing atypicalities were predictors of parent rated child anxiety. The findings of this study, therefore support Green and Sasson (2010) who suggest that anxiety is preceded by sensory over-responsivity (SOR) or sensory processing dysfunctions in young children with ASD.

Our review provided strong evidence for a relationship between anxiety and sensory atypicalities in ASD (Lidstone et al., 2014, Wigham et al., 2014, Mazurek et al., 2013, Green & Ben-Sasson, 2010, Ben-Sasson et al., 2008 & Pfeiffer et al., 2005). Results of the first study support these previous findings indicating that there is a significant correlation between sensory processing difficulties as rated by parents and parent, but not child reported, anxiety and also that SP atypicalities predict parent rated child anxiety.

Previous studies also show that SP dysfunctions are correlated with greater social impairment (Miller et al., 2005) and poor social performance (Baker et al., 2008). Our findings, however indicated no significant correlation between social phobia and SP, rather our data indicates that Separation Anxiety, Panic/Agoraphobia and Generalized anxiety were correlated with SP. To our knowledge these findings have not been reported elsewhere.

In our correlation analysis, we found a relationship between separation anxiety and SP. Regression analyses indicated that older age and sensory processing atypicalities are significant predictors of parent rated separation anxiety whilst EF makes no contribution. In addition, in our regression model, initially when autism severity was combined with age, autism severity was a stronger predictor of separation anxiety. However, when EF was added to the model, it was found that the amount of anxiety was affected more by the ASD severity than age and EF difficulties. This finding suggests that EF is potentially overlapping or interwoven with the core characteristics of autism as captured by our ASD severity measure, the SRS.

In terms of specific anxiety subscales, OCD has been found to correlate with EF difficulties by others (Zandt et al., 2009) as has social phobia with SP atypicalities (Bellini, 2006). We did not replicate these findings. When we explored predictors of panic and agoraphobia and found that sensory processing is a significant predictor of parent rated panic.

The final anxiety subtype that was associated with sensory processing difficulties is GAD. Our findings indicate that age and amount of SP atypicalities but not EF difficulties, predicted parent rated GAD in children with ASD. This finding further implies that SOR may precede GAD, which inconsistent with the Primary SOR model (Green and Sasson, 2010).

9.2.3 Exploring subgroups of children with ASD based on their profiles in relation to anxiety, EF and SP atypicalities, whilst taking into account other developmental characteristics (age, ability and ASD severity).

Previous research suggested that there may be an association between reduced performance on tasks of executive functioning, attentional switching and verbal working memory and the presence of greater levels of anxiety (Gunther et al.,2013; Toren et al. 2000, Hollocks et al. 2013). Utilising cluster analytic techniques our findings however, do not indicate a clear universal pattern of associations between executive functioning difficulties and anxiety problems in this group of children with ASD, rather we identified subgroups of children with ASD based on constellations of risk factors for anxiety.

The impact of development (age and IQ) and also ASD severity were examined to explore the relationship with anxiety in relation to SP dysfunctions. Results shows that age and ability are not consistently associated with vulnerability to SP difficulties and anxiety problems. The results further suggest that for some children high anxiety is associated with SP difficulties and the presence of higher levels of ASD severity. Our findings support some previous work indicating that unusual aversions to common sensory stimuli may cause anxiety for some children with ASD (White et al, 2009 & Bellini, 2006, Ben-Sasson et al., 2009; Liss et al., 2006; Pfeiffer et al., 2005).

Interestingly, in terms of the relationship between EF and anxiety, it was found that there is a less clear pattern, with EF scores varying markedly across clusters. Further examination indicates that in the main sensory atypicalities are making a stronger contribution to anxiety problems than EF. When all these constructs were combined (EF, SP and anxiety) it was found that high/low EF difficulties are better predicted by SP atypicalities rather than the heightened anxiety scores.

9.2.4 The associations between specific EF subtypes and anxiety (relationship between difficulties in particular EF tasks and OCD characteristics in children with ASD).

Our findings further support the need to not assume a one size fits all approach to analysis and suggest that difficulties in specific EF abilities do not consistently discriminate between children with heightened anxiety and those without. Our findings therefore do not support the studies that suggest poor executive functioning is associated with high anxiety in all children and adolescents with ASD (Hollock et al. 2014). However, results of the cluster analysis demonstrated that EF ability may contribute to the presence of OCD symptoms for some children who were perhaps most characterized by low Design Fluency (DF) subtest scores. This indicates that impairments in initiation and productivity as well as poor cognitive flexibility may contribute to heightened OCD symptoms in this sub-group of children with ASD (Korkman et al., 2007).

Our findings indicate that the Animal Sorting (AS) scores was consistently poor across all of the clusters, which indicates that poor initiation, cognitive flexibility and self-monitoring are a consistent feature of our sample suggesting cognitive flexibility is a core difficulty in this sample of children, which is consistent with Ozonoff et al. (1994), and Liss et al., (2001).

9.2.5 Relationships between parental reports of executive functioning, anxiety and restricted and repetitive behaviours in young people with ASD.

In our earlier study, we found no association between EF and anxiety on a performance-based measure on EF test battery (The NEPSY-II; Korkman et al, 2000b). However it could be argued that the measure used was lacking in terms of ecological validity and does not capture the real world impact of executive deficits. Therefore, in this follow up study parent reports of everyday executive function deficits were explored using the BRIEF (Gioia et al. 2000). In contrast to our earlier findings results indicated that parent reports of EF dysfunctions were associated with heightened anxiety in children with ASD. This is among the first study to find this relationship utilizing parent report of everyday EF. These inconsistencies will be reflected more fully later in this chapter, particularly in relation to shared method variance in the second study.

Based on parent reports, we also found that children with ASD with high OCD scores according to their parents engaged in more repetitive behaviours, particularly insistence on sameness behaviours. These findings support and build on the findings of Rodgers et al. (2012b), who found that children with

higher anxiety had more repetitive behaviours and specifically higher levels of insistence on sameness were associated with more anxiety.

We have also found that in our sample that set-shifting difficulties were associated with OCD symptoms, building on Mackinlay et al. (2006), who found that children with ASD were less efficient at planning, attempted fewer tasks, switched inflexibly between tasks and broke performance rules. Further exploratory analysis of the relationship between emotional monitoring and anxiety, indicated that lack of emotional monitoring was associated with higher anxiety, supporting findings by Leekam (2011). We also found that executive function difficulties were associated with higher levels of RRB, which further supports the findings of previous studies by Turner and Russell (1997).

Several areas of EF have been reported to be related to RRB, such as cognitive flexibility (Lopez et al. 2005) set-shifting and generativity (Turner and Russell, 1997) poor regulation and control (Leekam, 2011). We found that set-shifting deficits are associated with increased insistence of sameness but not repetitive motor behaviours. These findings suggest that set shifting deficits may underpin insistence of sameness which characterized by compulsive adherence to routine, and stereotyped, repetitive behaviours (Turner, 1995).

Further exploratory investigation on the relationship between specific EF deficits and RRB indicates that deficits in inhibition are associated with RRB, supporting findings by Lopez et al. (2005). This may explain why children with ASD often interrupt others, act impulsively and have trouble ‘putting the brakes on their actions’ (Gioia et al., 2000). Finally we have also found that children with ASD who have difficulty with initiation, present with more restricted and repetitive behaviours, which supports the Loftin et al. (2007) who have found that students with autism who have difficulty initiating social interactions exhibit more RRB.

9.2.6 Comparison of Anxiety among Children with ASD over Time

Previous research suggests that as children with ASD grow older anxiety may increase (Mayers et al., 2011). Our findings however indicate that there are no significant changes in parent reported anxiety over approximately a 20 month

period. In terms of specific anxiety problems, previous research indicates that specific phobias are more common in younger children, whereby OCD and social phobia are more common in adolescents (Ollendick et al., 2004). In this study, we have found no significant changes over time in most of the anxiety subscales, with the exception of OCD where we found higher scores at time one. The findings indicate that parent reported anxiety remains high over time for this group of young people but does not significantly increase further during our time period of investigation.

9.3 Strengths and Limitations

9.3.1 Strengths

The findings from our systematic review provide an overview of the extant literature which taken together may guide new directions for clinical practice among children with ASD who presented with EF, SP and anxiety features. In addition, this programme of work also was the first to examine EF as a possible neuropsychological correlate of anxiety in ASD together with sensory atypicalities. Moreover, this is one of the first studies that attempts to directly account for the potential heterogeneity in ASD by utilizing cluster analytic techniques to explore subgroups of children with ASD according to putative constellations of risk factors for anxiety. Results suggest that subgroups of children are identifiable and are characterized by different profiles of EF difficulties and SP atypicalities. This approach is essential and appropriate in determining groups of observations internally characterized by a high level of cohesion.

In our follow up study parent reports of everyday executive function deficits were explored using the BRIEF (Gioia et al. 2000) leading to the findings that parent reports of EF dysfunctions were associated with heightened anxiety in children with ASD. This is the first study to find this relationship utilizing parent report of everyday EF. To date, this is one of the first studies to have explored the neuropsychological correlates of anxiety together with the core symptoms of ASD (RRB) and explore the interplay in the relationship between these three variables. Furthermore, this study is also among the very few studies that have found a

relationship between EF and RRB. Finally, this study is one of the few that have explored potential changes over time in anxiety among children with ASD.

9.3.2 Limitations

a. Systematic Reviews

All articles evaluated in the review were accessed only in English language due to lack of translation resources. Data extraction was done only by the Principal Investigator, which may have introduced an element of subjectivity in the review process. In terms of, the inclusion criteria samples were comprised only of children in middle childhood who are high functioning, potentially limiting the generalizability of the conclusions.

b. Sample

The sample size in the programme of empirical work is small, but comparable with other studies (e.g. Rodgers et al. 2102a & b) that have adopted the same research framework. Post hoc power calculations ranged between 0.436 (43.6%) to 0.720 (72 %) indicating that some analyses were underpowered. Effect sizes ranged from 0.263 to 0.459, which represent medium to large effect sizes (Cohen, 1988) suggesting that despite low power some of the detected effects are likely to be clinically meaningful. The participants all had ability within the average range, it is therefore not possible for us to generalize these findings to less able young people with ASD. Future anxiety research should aim to recruit children from across the spectrum.

c. Design

The cross-sectional design utilised here provides only a snapshot of functioning at a single point only and cannot infer causality, future studies should adopt a longitudinal design and further investigate changes over time in these relationships.

This will allow further examination of whether the behavioural aspects of autism are both affected by and also effect neurocognitive development. Although some a very preliminary attempt was made here to undertake some longitudinal data collection the time frame between study 1 and 2 is brief compared to other studies that have used almost similar method (e.g.Green et al., 2012).

d. Measures

The majority of measures used in the empirical work (The NEPSY, SSP and SCAS, BRIEF) were not designed specifically for children use with autism. They were developed with and for use with typically developing children.

The NEPSY-II (EF domain) was utilized to measure EF in this study and there are interpretation guidelines provided for use with children with autism that we have followed. However, there are some psychometric concerns with several of the subtests comprising the EF domain. Test retest correlations coefficients for the Design fluency total score for age 5 to 12 were only .59. (Korkman et al., 2007a) and the correlation for the Animal Sorting subtest ranged from .08 to .24. Korkman and colleagues account for the low correlations suggesting that the various subtests are measuring different functions within the domain. Therefore, in this study, the combined EF scores was used as it was derived by combining two measures within the subtest (e.g., completion time and errors on the inhibition naming score). Even though there is still a lack of empirical research on the subcomponents of EF functions and the factors they are purported to measure (Miller, 2009). NEPSY-II is the only neuropsychological battery developed specifically for children and adolescents.

Reviews on anxiety measures in children with ASD demonstrate little consistency in terms of how anxiety symptoms are measured, and considerable variability in how respondents (e.g., parent, child) perceived such symptoms. In our study the parent

and child rated SCAS was used as a measure of anxiety symptoms. whilst not developed for or validated with children with ASD a recent systematic review of the properties of tools used to measure outcomes in anxiety intervention studies for children with ASD found that it is a robust measure for anxiety in children with ASD (Wigham and McConachie, 2014).

The SSP has been used widely to assess sensory processing dysfunctions in children ASD (e.g. Lane et al., 2010, Chen et al, 2009, Ben-Sasson et al., 2009, Ashburner et al., 2008, Leekam et al., 2007, Tomchek & Dunn, 2007).

Obsessions and compulsions in Obsessive-Compulsive Disorders (OCD) and Autism-related obsessive-compulsive phenomena (AOCP) are often regarded as an overlapping class of behaviours (Fischer-Terworth and Probst 2009) and the repetitive and ritualistic behaviours inherent in ASD can be difficult to tease apart from the compulsive behaviours in OCD (Gjevik et al., 2011). As for the CHOCHI-R, we have attempted to address this issue by conducting the semantic evaluation of the scale and used only the items that would be more likely to be characteristic of OCD in this ASD sample.

e. Statistical analyses

In the earlier part of analysis in this program of work, we adopted correlational analyses. Due to the heterogeneity associated with ASD, the potential relationships between anxiety and other features associated with ASD, such as EF deficits and sensory processing atypicalities, may not be detectable at group level. Therefore, exploring data at subgroup level utilizing cluster analytic technique is an important step forward.

However, cluster analysis is a descriptive technique. The solution strongly depends upon the analyst's choices (experimenter bias). Cluster analysis will always derive a group structure even if there the associations are weak between the constructs.

When applying a cluster analysis it is hypothesized that the groups exist. Cluster analysis results also should not be generalized. To overcome this, data transformations and variable selections were undertaken before clustering. This helps to reduce experimenter bias and certain degree of generalization can be made, though caution should be taken with interpretation.

f. Common Method variance

All of our significant findings are from parent rated measures (Parent rated SCAS and SSP, BRIEF, RBQ) and we did not find strong agreement between child and parent dyads on the SCAS. It is hard to interpret what this lack of agreement means however it is important to note it in the context that the significant findings were largely related to parent rated measures. This could result from common method variance (CMV) problems. Consequently, the possibility arises that method variance has inflated the observed correlations between variables artifactually. Future work should strive to derive data from multiple sources, both experimental and self and proxy report to minimise the influence of shared method variance.

9.4 Practical Implications

Due to the identification of potentially identifiable subgroups of children with autism based on their EF, SP and anxiety, we cannot assume one profile will fit into all children with ASD. Therefore, this research emphasises how important it is to adopt an individualized formulation for each child with ASD. In this study also, we have found that anxiety scores remained high over time. Therefore, anxiety does not naturally diminish with time for children with ASD. It is recommended that children with ASD are assessed regularly in terms of their anxiety symptoms. Specific effective interventions tailored for children with ASD need to be implemented either as individual, group or family therapies.

Another important issue is centrality around SP atypicalities in subgroups of children with ASD. Sensory processing has a major impact on psychological well-being as well as daily functioning. Therefore, clinicians should be made aware of this and

bear this issue in mind whenever approaching children and families with autism. Whenever children with autism and their families present at the clinic, they should be asked about major sensory abnormalities presented in their child, how they affect functionality of the child and how parents manage these behaviours in their child.

Psycho-education about SP abnormalities for families who have ASD children and how to manage these difficulties are very important.

It is important to note also that we have also found SP atypicalities are associated with heightened anxiety. Therefore, clinicians may observe those children with SP difficulties may experience heightened anxiety as well.

It is well recognized also that the best-known intervention for SP abnormalities in ASD involve an occupational therapy programs that are specifically tailored to the needs of the individualized children with ASD. Therefore, efforts should be made to train psychiatrists, psychologists, occupational therapists and other mental health professionals working with the ASD population to evaluate patients for sensory as well as anxiety symptoms. Individualized intervention plans should be developed using multidisciplinary approaches.

We also found that RRBs, particularly insistence on sameness are associated with OCD. On the other hand, cognitive inflexibility is the main EF difficulty faced by children in our sample. Therefore, it is important to understand the waxing and waning of these issues in children with ASD. Parents should be asked about routine behaviour indicating ‘stuck in set’ behaviour. They may need to indicate whether these behaviour are part of RRB or OCD or cognitive inflexibility simultaneously occurred and overlap in their children.

9.4 Implications for future research

With regard to future directions, our review has highlighted that future studies should attempt to recruit a population based sample. If clinical samples are being recruited, they should be compared to non-clinical, community ASD groups to examine the uniqueness of the symptoms to treatment seeking youth with ASD. Most of the studies being reviewed utilized a small sample size. Future studies should attempt to recruit adequate samples guided by apriori power calculations (Cohen, 1988).

Investigation in a larger sample size, whilst maintaining a focus on heterogeneity, is needed to enable further specification of the associations between specific EF deficits and specific anxiety types and RRB subtypes. Longer time frames with participants assessed at two or more time points in order to examine the patterns of changes in anxiety over time are also recommended. An attempt should be made to examine a broader age range to determine developmental trajectories more fully. Studies should also focus more on the less able children with ASD to ensure all points in the spectrum are represented.

Replication studies adopting a research framework that addresses the potential biasing effects of method variance in their research is needed. Data should be collected from multiple sources, methods or informants. Careful attempts also should be made to reduce potential confounds during the choice of measures as well as during testing procedures. In addition, further research is also required to determine construct and discriminant validity of questionnaires measures.
More research is needed on the underlying neurophysiology of EF, SP and anxiety symptoms and on the relationships between them and the other symptoms and comorbidities related to ASD. Further understanding of the neural basis of EF, SP and anxiety in children with ASD should also be explored in future studies utilising neuroimaging techniques to further enhance our understanding of the neuropsychological correlates of anxiety in ASD.

In terms of cognitive flexibility measures, experimental measures must evolve to reflect mechanistic models of flexibility deficits. This is because previous studies found that there is a large gap between the day-to-day behavioural flexibility and that measured with the presently available cognitive flexibility tasks (Geurts et al., 2009). Therefore, in order to advance the field, ecologically valid measures are required to be able to resolve the paradox between cognitive and behavioural inflexibility. In the future also, it is critical to investigate how widespread a stuck-in-set perseveration may be within subgroups of children with ASD.

Future studies should also should focus on assessing a wide range of different EF functions (Hill, 2004) using more ecologically valid real world measures. The combinations of physiological methods, neuropsychological batteries, questionnaires measure as well as behavioural observation at home or classroom settings will enhance the understanding of day to day anxiety, RRB and EF difficulties as well as the interplay of these with core difficulties of ASD.

SP symptoms have been correlated with several other problematic symptoms and behaviours associated with ASD, including RRBs, intellectual disability, migraine headache and GI complaints (Mazurek et al., 2013). Future work also should incorporate assessments of assess adaptive functioning level and quality of life of children with ASD associated with these comorbidities. Investigation of how these phenomena relate to endophenotype may shed light on how to help improve the quality of life of children with ASD.

The potential relationship between executive dysfunctions and repetitive behaviours in relation to specific EF functions is also worthy of further work. Future work should focus on profiling executive function and sensory atypicalities across the lifespan. In those children who show no clear executive deficits in test batteries, performance in naturalistic settings involving executive functions, such as in the classroom or during play activities will warrant some research.

Cross-culturally, the association between SOR and anxiety was not replicated in a sample of Japanese children with ASD (Tsuji et al, 2009). The children with hypersensitivities did not differ significantly on the anxiety measure compared to the group with no hypersensitivities. Further investigation in other cultures is helpful in order established whether this issue is universal across culture or other factors could be taken into consideration when addressing this relationship cross-culturally.

9.5 Summary

We set out in this thesis to attempt to explore the putative relationships between anxiety and executive deficits and sensory atypicalities in children with ASD. Findings indicated no association between EF difficulties and anxiety. High anxiety was found to be more associated with SP atypicalities and the presence of higher levels of ASD severity. Increasing age and high SP atypicalities were found to be predictors of parent rated child anxiety. Separation Anxiety, Panic/Agoraphobia and Generalized anxiety were correlated with sensory difficulties findings which have not been reported elsewhere. When EF difficulties were captured via parent report they were associated with heightened anxiety and we also found that children with higher parent reported OCD scores tended to engage in more RRB, specifically insistence on sameness. No significant changes over time found in most of the anxiety subscales, except OCD scores were found higher at time one. Overall, findings supports previous research that anxiety is high in children with ASD and remains high over time and is associated with sensory processing atypicalities. The relationship between executive function and anxiety varied as a function of the source of the data. Cluster analysis illustrated identifiable subgroups of children with ASD based on constellations of risk factors for anxiety, which has important implications for both research and clinical practice, emphasising how essential it is take into account heterogeneity within the ASD spectrum.

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APPENDICES

(Copies for all measures were not included in appendices due to copyright)

Appendix A

Electronic databases searched and number of hits acquired at stage 1

Search platform	Database	Number of hits
1.ISI Web of Knowledge	Web of Science, including Science Citation Index Expanded & Social Citation Index (1970-2014)	565
2.Ovid	Embase (1980 to 2014 week 52)	520
	Medline (1946 – November week 3 2014)	352
	PsychINFO (1987 – December week 5 2014)	306
3.Scopus	Scopus (1960 - Present)	31
	Total number of hits before sifting	
	1774	

Appendix B

Potential Threat Scoring Criteria

Domain	Criterion	Classification	Scoring Criteria
INTRODUCTION	Are the aims, hypotheses and objectives clearly described for the constructs being studied (EF and anxiety)?	0-Not addressed/covered	The aims and hypothesis of the study are not stated or covered
		1-Poorly addressed	The aims and hypothesis of the study are unclear or not stated
		2-Adequately addressed	The aims and hypothesis are clearly stated but lack of sufficient detail
		3-Well-addressed	The aims and hypothesis are clear and provide sufficient details
METHODOLOGY **1. PARTICIPANTS**	Does the recruitment methodology evidence an attempt to gain a sample that is representative of the study population?	0-Not covered	Recruitment sources were not reported
		1-Poorly addressed	A highly selective recruitment method was used and not controlled for
		2-Adequately addressed	A population based sample was targeted but no attempts were made to control for differences between participants and non-participants

		3-Well-addressed	A population based sample was targeted (e.g. all eligible patients in a geographical area) and differences between participants and non-participants was controlled for.
	Are the inclusion and exclusion criteria justified?	0 – Not reported	Inclusion/exclusion criteria not reported
		1 – Poorly reported	Inclusion/exclusion criteria poorly reported with no justification for decisions made
		2-adequately reported	Inclusion/exclusion criteria reported but lacking in sufficient detail/justification for decisions made.
		3-well reported	Inclusion/exclusion criteria clear and fully justified
	Are sample characteristics described (age, gender, ASD subtypes, Comorbidities, medication use and	0 – Not reported	Participant characteristics not reported
		1 – Poorly reported	Participant characteristics poorly reported with many omissions

	demographic variables)?	2 – Adequately reported	Participant characteristic adequately reported with few omissions
		3 – Well reported	Participant characteristics are well reported
	Was ASD diagnosis confirmed for the study?	0 - Not covered	Paper reports that diagnoses were confirmed but does not provide detail how.
		1 - Poorly addressed	ASD diagnoses have not been confirmed for this study. Inclusion relies on previous diagnoses.
		2 - Adequately addressed	Diagnoses have been confirmed for this study, but not by use of a gold-standard tool.
		3 - Well-addressed	Diagnoses have been confirmed for this study by use of a 'gold-standard' diagnostic tool (i.e. ADOS or ADI-R).
	Was level of cognitive functioning of participants assessed?	0 - Not covered	Level of cognitive functioning is reported but method of assessment is unclear.
		1 - Poorly addressed	Level of cognitive functioning is not reported.
		2 - Adequately addressed	Level of cognitive functioning is reported but is based on previous (non-recent) assessment or on method other than standardised instrument.
		3 - Well-addressed	Level of cognitive functioning is reported and based on assessment using a standardised instrument and was

			assessed either for the study or within the preceding 3 years.
	Are the participants are appropriate to answer the research question?	0 –Not addressed	Participants not appropriate to answer research question
		1 – Poorly addressed	Participants partially appropriate to answer research question
		2 – Adequately addressed	Participants appropriate but limited to answer research question
		3 – Well addressed	Participants appropriate to fully answer research question
2.DESIGN	Was the design appropriate for the study question? (e.g., for knowledge level about this issue, outcomes, ethical issues, etc.)	0 – Not addressed	Design not appropriate to research question
		1 – Poorly addressed	Design somewhat appropriate to research question
		2 – Adequately addressed	Design seems appropriate to research question but could be improved
		3 – Well addressed	Design highly appropriate to answer research question
	Any biases that may have been operating have been specified and the direction of their influence on the results were mentioned?	0 – Not addressed	No confounds addressed
		1 – Poorly addressed	Potential confounds poorly addressed
		2 – Adequately addressed	Potential confounds adequately addressed but could be improved
		3 – Well addressed	Potential confounds well addressed

3.MEASURES	Was anxiety measured using standardised, valid and reliable measures?	0 - not addressed	Non standardised or validated measures are used, no reported evidence of validity or reliability provided.
		1 - Poorly addressed	Standardised measure used, evidence of validity and reliability not provided in this study, but reference to cited studies provide evidence of acceptable properties
		2 - Adequately addressed	Standardised measures are used and evidence of good psychometric properties provided in this study.
		3 - Well addressed	Standardised measures are used and evidence of good psychometric properties provided in this study WITH SUFFICIENT DETAILS.
	Were the measures of anxiety used appropriate for use with an ASD population?	0 - not addressed	No evidence that tool is appropriate for ASD population.
		1 - Poorly addressed	Tool has not been standardised for ASD population but is widely used in ASD research or evidence of acceptable psychometric properties provided in this study.
		2 - Adequately addressed	Evidence that tools used have been standardised and validated for use with ASD population.
		3 - Well addressed	Evidence that tools used have been standardised and validated for use with ASD population WITH

			SUFFICIENT DETAILS
	Was EF measured using standardised, valid and reliable measures?	0 - not addressed	Non standardised or validated measures are used, no reported evidence of validity or reliability provided.
		1 - Poorly addressed	Standardised measure used, evidence of validity and reliability not provided in this study, but reference to cited studies provide evidence of acceptable properties
		2 - Adequately addressed	Standardised measures are used and evidence of good psychometric properties provided in this study.
		3 - Well addressed	Standardised measures are used and evidence of good psychometric properties provided in this study WITH SUFFICIENT DETAILS.
	Were the measures of EF used are appropriate for use with an ASD population?	0 - not addressed	No evidence that tool is appropriate for ASD population.
		1 - Poorly addressed	Tool has not been standardised for ASD population but is widely used in ASD research or evidence of acceptable psychometric properties provided in this study.
		2 - Adequately addressed	Evidence that tools used have been standardised and validated for use with ASD population.
		3 - Well addressed	Evidence that tools used have been standardised and validated for use with ASD population WITH

			SUFFICIENT DETAILS
	Based on the above, how well was assessment done to reduce bias and to gain accurate outcome measures?	0 - Unable to determine	There is no reporting
		1 - Poor	Attempt made to reduce bias and gain accurate outcome measures but not sufficient
		2 - Adequate	Adequate attempt was made to reduce bias and gain accurate outcome measures
		3 - Good	All the attempt needed was made to reduce bias and gain accurate outcome measures and details was sufficient provided
RESULTS/ANALYSIS	Is the statistical analysis appropriate to the design?	0 – Not covered	Insufficient information is provided to judge the appropriateness of the analysis
		1 – Poorly covered	Inappropriate statistical tests were used.
		2 – Adequately covered	The analytic strategy is appropriate but has some limitations (e.g. other analytical strategy would have been more powerful or some assumptions have been violated) *or* limited statistical analysis was carried out but there is no evidence of bias.
		3 – Well covered	The analytic strategy is appropriate to the design and data.

	Are descriptive statistics provided?	0 – Not reported	Descriptive statistics not provided
		1 – Poorly reported	Descriptive statistics poorly reported (several omissions)
		2 – Adequately reported	Descriptive statistics adequately reported (some omissions)
		3 – Well reported	Descriptive statistics well reported
	Is appropriate supplementary information provided (i.e. effect sizes, power)	0 – Not reported	No supplementary information provided
		1 – Poorly reported	Limited supplementary information provided
		2 – Adequately reported	Adequate supplementary information (minimal omissions)
		3 – Well reported	Supplementary information well reported
	Do the results allow inferences to be made about the relationship between EF and anxiety in ASD specifically?	0 – Not addressed	Results do not allow any inferences to be made
		1 – Poorly addressed	Results allow minimal/indirect inferences to be made
		2 – Adequately addressed	Results allow inferences to be made but these are limited
		3 – Well addressed	Results allow strong inferences to be made
DISCUSSION	Do the conclusions follow adequately from results?	0 –Not reported	Conclusions not reported
		1 – Poorly reported	Conclusions poorly reported/not grounded in results
		2 – Adequately reported	Conclusions adequately reported but lacks clarity
		3 – Well reported	Conclusions clearly reported and grounded in results

	Are limitations acknowledged?	0 –Not reported	No acknowledgement of limitations
		1 – Poorly reported	Some acknowledgement of limitations but not all, or no consideration given to the impact of limitations on interpretation.
		2 – Adequately reported	The main limitations are acknowledged and consideration was given to the impact of limitations on interpretation.
		3 – Well reported	Clear acknowledgement of main limitations of the study and consideration given to the impact of these on interpretation.

Appendix C

Electronic databases searched and number of hits acquired at stage 2

Search platform	Database	Number of hits
1. ISI Web of Knowledge	Web of Science, including Science Citation Index Expanded & Social Citation Index (1970-2014)	646
2. Ovid	Embase (1980 to 2014 week 52)	64
	Medline (1946 – November week 3 2014)	1
	PsychINFO (1987 – December week 5 2014)	2
3. Scopus	Scopus (1960 - Present)	99
	Total hits acquired	***832***

Appendix D

Potential Threat Scoring Criteria for review stage 2

Domain	Criterion	Classification	Scoring Criteria
A. INTRODUCTION	Does the definition and concept of sensory atypicalities was being defined accordingly?	0-Not addressed/covered	The definition and concept were not stated or covered
		1-Poorly addressed	The definition and concept was poorly reported or unclear
		2-Adequately addressed	The definition and concept were adequately reported, but lack of sufficient detail
		3-Well-addressed	The definition and concept are well reported, clear and sufficient details provided.
	Are the aims, hypotheses and objectives clearly described for the constructs being studied (SP and anxiety)?	0-Not addressed/covered	The aims and hypothesis of the study are not stated or covered
		1-Poorly addressed	The aims and hypothesis of the study are unclear or not stated

		2-Adequately addressed	The aims and hypothesis are clearly stated but lack of sufficient detail
		3-Well-addressed	The aims and hypothesis are clear and provide sufficient details
B. METHODOLOGY **1. PARTICIPANTS**	Does the recruitment methodology evidence an attempt to gain a sample that is representative of the study population?	0-Not addressed/covered	Recruitment sources were not reported
		1-Poorly addressed	A highly selective recruitment method was used and not controlled for
		2-Adequately addressed	A population based sample was targeted but no attempts were made to control for differences between participants and non-participants
		3-Well-addressed	A population based sample was targeted (e.g. all eligible patients in a geographical area) and differences between participants and non-participants was controlled for.
	Are the inclusion and exclusion criteria justified?	0 – Not reported	Inclusion/exclusion criteria not reported
		1 – Poorly reported	Inclusion/exclusion criteria poorly reported with no justification for decisions made
		2-adequately reported	Inclusion/exclusion criteria reported but lacking in sufficient detail/justification for decisions made.

		3-well reported	Inclusion/exclusion criteria clear and fully justified
	Are sample characteristics described (age, gender, ASD subtypes, Comorbidities, medication use and demographic variables)?	0 – Not reported	Participant characteristics not reported
		1 – Poorly reported	Participant characteristics poorly reported with many omissions
		2 – Adequately reported	Participant characteristic adequately reported with few omissions
		3 – Well reported	Participant characteristics are well reported
	Was ASD diagnosis confirmed for the study?	0 - Not covered	Paper reports that diagnoses were confirmed but does not provide detail how.
		1 - Poorly addressed	ASD diagnoses have not been confirmed for this study. Inclusion relies on previous diagnoses.
		2 - Adequately addressed	Diagnoses have been confirmed for this study, but not by use of a gold-standard tool.
		3 - Well-addressed	Diagnoses have been confirmed for this study by use of a ‘gold-standard’ diagnostic tool (i.e. ADOS or ADI-R).

2. DESIGN	Was level of cognitive functioning of participants assessed?	0 - Not covered	Level of cognitive functioning is reported but method of assessment is unclear.
		1 - Poorly addressed	Level of cognitive functioning is not reported.
		2 - Adequately addressed	Level of cognitive functioning is reported but is based on previous (non-recent) assessment or on method other than standardised instrument.
		3 - Well-addressed	Level of cognitive functioning is reported and based on assessment using a standardised instrument and was assessed either for the study or within the preceding 3 years.
	Are the participants are appropriate to answer the research question?	0 –Not addressed	Participants not appropriate to answer research question
		1 – Poorly addressed	Participants partially appropriate to answer research question
		2 – Adequately addressed	Participants appropriate but limited to answer research question
		3 – Well addressed	Participants appropriate to fully answer research question
	Was the design appropriate for the study question? (e.g., for knowledge level about this	0 – Not addressed	Design not appropriate to research question
		1 – Poorly addressed	Design somewhat appropriate to research question
		2 – Adequately	Design seems appropriate to research question but

3. MEASURES	issue, outcomes, ethical issues, etc.)	addressed	could be improved
		3 – Well addressed	Design highly appropriate to answer research question
	Any biases that may have been operating have been specified and the direction of their influence on the results were mentioned?	0 – Not addressed	No confounds addressed
		1 – Poorly addressed	Potential confounds poorly addressed
		2 – Adequately addressed	Potential confounds adequately addressed but could be improved
		3 – Well addressed	Potential confounds well addressed
	Was anxiety measured using standardised, valid and reliable measures?	0 - not addressed	Non standardised or validated measures are used, no reported evidence of validity or reliability provided.
		1 - Poorly addressed	Standardised measure used, evidence of validity and reliability not provided in this study, but reference to cited studies provide evidence of acceptable properties
		2 - Adequately addressed	Standardised measures are used and evidence of good psychometric properties provided in this study.
		3 - Well addressed	Standardised measures are used and evidence of good psychometric properties provided in this study WITH SUFFICIENT DETAILS.

	Were the measures of anxiety used appropriate for use with an ASD population?	0 - not addressed	No evidence that tool is appropriate for ASD population.
		1 - Poorly addressed	Tool has not been standardised for ASD population but is widely used in ASD research or evidence of acceptable psychometric properties provided in this study.
		2 - Adequately addressed	Evidence that tools used have been standardised and validated for use with ASD population.
		3 - Well addressed	Evidence that tools used have been standardised and validated for use with ASD population WITH SUFFICIENT DETAILS
	Was SP measured using standardised, valid and reliable measures?	0 - not addressed	Non standardised or validated measures are used, no reported evidence of validity or reliability provided.
		1 - Poorly addressed	Standardised measure used, evidence of validity and reliability not provided in this study, but reference to cited studies provide evidence of acceptable properties
		2 - Adequately addressed	Standardised measures are used and evidence of good psychometric properties provided in this study.
		3 - Well addressed	Standardised measures are used and evidence of good psychometric properties provided in this study

			WITH SUFFICIENT DETAILS.
	Were the measures of SP used are appropriate for use with an ASD population?	0 - not addressed	No evidence that tool is appropriate for ASD population.
		1 - Poorly addressed	Tool has not been standardised for ASD population but is widely used in ASD research or evidence of acceptable psychometric properties provided in this study.
		2 - Adequately addressed	Evidence that tools used have been standardised and validated for use with ASD population.
		3 - Well addressed	Evidence that tools used have been standardised and validated for use with ASD population WITH SUFFICIENT DETAILS
	Based on the above, how well was assessment done to reduce bias and to gain accurate outcome measures?	0 - Unable to determine	There is no reporting
		1 - Poor	Attempt made to reduce bias and gain accurate outcome measures but not sufficient
		2 - Adequate	Adequate attempt was made to reduce bias and gain accurate outcome measures
		3 - Good	All the attempt needed was made to reduce bias and gain accurate outcome measures and details was

			sufficient provided
C. RESULTS/ANALYSIS	Is the statistical analysis appropriate to the design?	0 – Not covered	Insufficient information is provided to judge the appropriateness of the analysis
		1 – Poorly covered	Inappropriate statistical tests were used.
		2 – Adequately covered	The analytic strategy is appropriate but has some limitations (e.g. other analytical strategy would have been more powerful or some assumptions have been violated) *or* limited statistical analysis was carried out but there is no evidence of bias.
		3 – Well covered	The analytic strategy is appropriate to the design and data.
	Are descriptive statistics provided?	0 – Not reported	Descriptive statistics not provided
		1 – Poorly reported	Descriptive statistics poorly reported (several omissions)
		2 – Adequately reported	Descriptive statistics adequately reported (some omissions)
		3 – Well reported	Descriptive statistics well reported
	Is appropriate supplementary information provided (i.e. effect sizes, power)	0 – Not reported	No supplementary information provided
		1 – Poorly reported	Limited supplementary information provided
		2 – Adequately	Adequate supplementary information (minimal

		reported	omissions)
		3 – Well reported	Supplementary information well reported
	Do the results allow inferences to be made about the relationship between SP and anxiety in ASD specifically?	0 – Not addressed	Results do not allow any inferences to be made
		1 – Poorly addressed	Results allow minimal/indirect inferences to be made
		2 – Adequately addressed	Results allow inferences to be made but these are limited
		3 – Well addressed	Results allow strong inferences to be made
D. DISCUSSION	Do the conclusions follow adequately from results?	0 –Not reported	Conclusions not reported
		1 – Poorly reported	Conclusions poorly reported/not grounded in results
		2 – Adequately reported	Conclusions adequately reported but lacks clarity
		3 – Well reported	Conclusions clearly reported and grounded in results
	Are limitations acknowledged?	0 –Not reported	No acknowledgement of limitations
		1 – Poorly reported	Some acknowledgement of limitations but not all, or no consideration given to the impact of limitations on interpretation.
		2 – Adequately reported	The main limitations are acknowledged and consideration was given to the impact of limitations on interpretation.
		3 – Well reported	Clear acknowledgement of main limitations of the study and consideration given to the impact of these

			on interpretation.

Appendix E

Ethical Approval and indemnity for Study 1

16 April 2013

Nooraini Darus
Institute of Neuroscience

Faculty of Medical Sciences

Newcastle University
The Medical School
Framlington Place
Newcastle upon Tyne
NE2 4HH United Kingdom

Professor Michael Whitaker
FIBiol FMed Sci
Dean of Research & Innovation

FACULTY OF MEDICAL SCIENCES: ETHICS COMMITTEE

Dear Nooraini

Title: Anxiety In Autism Spectrum Disorder (ASD): The Influence of Executive and Sensory Processing Dysfunctions
Application No: 00529_1/2013 (Amendment)

On behalf of the Faculty of Medical Sciences Ethics Committee, I am writing to confirm that the ethical aspects of your proposal have been considered and your study has been given ethical approval.

The approval is limited to this project: **00529_1/2013 (Amendment)**. If you wish for a further approval to extend this project, please submit a re-application to the FMS Ethics Committee and this will be considered.

During the course of your research project you may find it necessary to revise your protocol. Substantial changes in methodology, or changes that impact on the interface between the researcher and the participants must be considered by the FMS Ethics Committee, prior to implementation.*

At the close of your research project, please report any adverse events that have occurred and the actions that were taken to the FMS Ethics Committee.*

Best wishes,

Yours sincerely

M. Holbrough

Marjorie Holbrough
On behalf of Faculty Ethics Committee

cc.
Professor Michael Whitaker, Dean of Research & Innovation
Ms Lois Neal, Assistant Registrar (Research Strategy)

*Please refer to the latest guidance available on the internal Newcastle Biomedicine web-site.

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THE QUEEN'S ANNIVERSARY PRIZES
FOR HIGHER AND FURTHER EDUCATION
2009

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To Whom It May Concern

Our ref: NK/IND 11 July, 2011

Zurich Municipal Customer: University of Newcastle

This is to confirm that University of Newcastle have in force with this Company until the policy expiry on 31 July 2012 Insurance incorporating the following essential features:

Policy Number: NHE-08CA03-0013

Limit of Indemnity:

Public Liability:	£ 25,000,000	any one event
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Pollution:		aggregate during any one period of insurance
Employers' Liability:	£ 25,000,000	any one event inclusive of costs

Excess:

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The policy documents should be referred to for details of full cover.

Yours faithfully

Underwriting Services
Zurich Municipal
Farnborough

Zurich Municipal
Zurich House
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Farnborough
Hampshire
GU14 6GB

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Direct Phone: 01252 387859
Direct Fax: 01252 375893
E-mail allson.cliff@zurich.com

Appendix F

Parental Information Sheet and Consent Form for Study 1

Exploring Executive Functions, Sensory Processing and Anxiety in Young people with Autism Spectrum Disorder (ASD)

You and your child are invited to take part in this study. Before you decide to take part it is important for you to understand why the study is being done and what it involves. Please take time to read the following information carefully and discuss it with others if you wish. Please contact us if there is anything that is not clear or if you would like some more information.

What is the project about?

We are interested in identifying subgroups of children with ASD and anxiety according to their performance on executive and the presence of sensory processing difficulties.

We were also interested in describing any associations between anxiety subtypes in children with ASD according to their performance on executive function and the presence of sensory processing difficulties.

Why have we been invited to take part?

You have been chosen because you have a child age between 8 to 16 years with ASD. We will be asking about 30-40 children with ASD to take part in the study.

Do we have to take part?

Taking part in this study is entirely voluntary. It is up to you to choose whether to take part. If you do decide to take part, you can withdraw from the study at any time without giving a reason and this will not affect the education that your child receives from his/her school. If you stop from the study we will ask you if we can use data collected from you up until that point.

What will happen if we take part?

If you decide to take part we will ask you and your child to sign a consent form and send them back to us via your child's school. We will then arrange to see your child at school and send some questionnaires to you to complete. After you have consented to take part in the study, we will arrange to come to your child's school to see them. We will also send some questionnaires to you to complete.

What will my child are asked to do?

We will ask your child to fill in a questionnaire, which is the Spence children's Anxiety Scale, which measure feelings related to anxiety. It normally takes around 10 minutes to answer the questions. We will also ask them to complete a few tasks from ability tests, including the Wechsler Abbreviated Scale of Intelligence (WASI), which will give us an idea of your child's general ability. It will take approximately 30 minutes for your child to complete this task. In order to measure executive functioning, A Developmental NEuroloPSYcological Assessment –Version II (NEPSY-II) will be used. For the purpose of this research, the Executive Function/Attention subtests will be administered. It takes around 15 minutes to administer.

All of these questionnaires have been developed for use with children and young people. It takes 55 minutes altogether to complete all the above tasks.

What will I be asked to do?

We will also ask you to complete a series of questionnaires: the parent versions of the Spence children's Anxiety Scale-Parent report, the Sensory Profile, The Children's Yale–Brown Obsessive-Compulsive Scale (CY-BOCS) - parent-report questionnaire and The Social Communication Questionnaire (SCQ).

These questionnaires will provide us with information about your child's autistic symptoms, specific anxiety feeling, past and present OCD symptoms and your child's responses to sensory events in everyday life.

It will take about 1 hour for you to complete these questionnaires. We will send these questionnaires to you and ask you to post them back to us in a pre-paid envelope.

Will my taking part in this study be kept confidential?

Data collected about you will be looked at by members of the research team, and may also be looked at by people authorised to check that the study is being carried out correctly. We will follow ethical and legal practice and all information about you will be handled in confidence. You and your child's data will be stored in a locked filing cabinet and will also be anonymised before being stored on a computer, with the key to your identity stored in a separate file. The information gathered during the research will be presented at conferences, used to write journal articles and to support an application for a larger UK ASD study. We will not use your or your child's

name on anything published or presented about the study. However if your child happens to have a very high score on one of the anxiety measures, or makes a disclosure that suggests they may be at risk we will discuss this with a clinician.

Who is organising and funding the research?

This research is being funded by Newcastle University. United Kingdom.

Who has reviewed the study?

The study has been reviewed and approved by Newcastle University, Research Ethics Committee.

Can I talk to someone before agreeing to take part?

If you would like to further information about this project before or after meeting the researcher you can contact Dr Jacqui Rodgers on 0191 222 7562, Jacqui.rodgers@ncl.ac.uk. You are welcome to ask us any questions or discuss any worries you may have.

Thank you for reading this information sheet

Parent Consent Form

Please initial each box.

I confirm that I have read and understood the information sheet for the above study. I have had the opportunity to consider the information and ask questions and have had these answered satisfactorily. ☐

I understand that my participation is voluntary, and that I am free to withdraw at any time, without giving any reason, without affecting the care that I or my family receives.
If I withdraw from the study, I understand that you will ask me if data collected from me up until that point can still be included in the study. ☐

I understand that if I decide to withdraw from the study, I will be asked if data collected from me up until that point can be included in the study. ☐

I understand that data collected during the study may be looked at by individuals from regulatory authorities, where it is relevant to my taking part in this research. I give permission for these individuals to have access to my records. ☐

I understand that data may be retained for use in future projects, subject to approval by a Research Ethics Committee.• ☐

I have been asked to give consent for my daughter/son to participate in this research study which will involve him/her completing a questionnaires tasks, a decision making tasks and an ability task. ☐

I understand that she/he will also be asked to give permission and that her/his wishes will be respected. ☐

I agree to taking part in the study. ☐

I consent voluntarily for my child to participate in this study and understand that I have the right to withdraw her/him from the study at any time, without giving a reason. ☐

I understand that data collected from me may be looked at by individuals from regulatory authorities where it is relevant to my child taking part in his research. I give permission for these individuals to have access to the data.

Name of Young Person _____

Name of Parent/Carer_____

Date _____ Signature _____

Name of Researcher _____

Date _____ Signature _____

Appendix G

Young Person Information Sheet and Assent Form

Exploring Executive Functions, Sensory Processing and Anxiety in Young people with Autism Spectrum Disorder (ASD)

What is this all about?

Hello, my name is Nooraini Darus and I would like to invite you to take part in a research study. We are interested in finding out if the way you think about things affects the way you do things.

In order to help you to decide about taking part, I would like you to read this letter which tells you about the study. It is very important that you understand what the study is about, so please discuss it with your family if you want to.

Why have I been chosen?

You have been chosen because you are a young person aged between 8 to 16 years old. We will also be asking about 30 to 40 young people to take part in this study.

Do I have to take part?

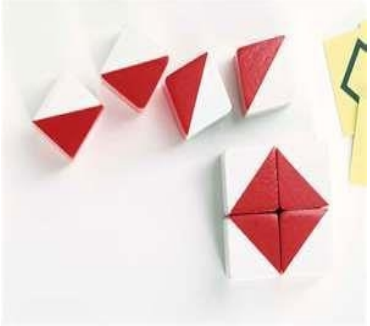
No. Whether or not you take part is completely up to you. If you agree to take part and don't want to do it anymore you are free to change your mind or stop at any time without giving a reason.

What will happen if I take part?

If you decide to take part, I will ask you to do:

Some puzzles.
Answer some questions

One of the puzzles will look bit like this:



The other task will look a bit like this

All the tasks have been designed for young people and are really fun and easy to do! It will take about 1 hour to do.

I will also be asking your parent some questions too.

Where will this happen?

You and your family can decide where you want to do the puzzles. I could come and see you at your school, in your home or if you like you and your parent can come and see me at the university.

Who will know that I am taking part?

The only people that will know you took part and how you did on the tasks will be the research team. No one else will know.

Can I talk to someone before agreeing to take part?

Yes, if you or your parents have any questions and/or you are interested in taking part in the research study you can call or email me as follows:

Nooraini Darus

Phone: 0191 222 3466
E-mail: n.darus@ncl.ac.uk

You can also get in touch with my other team member,
Dr Jacqui Rodgers on 0191 222 7562
(Jacqui.rodgers@ncl.ac.uk)

I would like to take part

If you think you might like to take part in this study, then you and your parents can fill in the form sent with this letter and send it back and I will get in touch to arrange a time to meet

Thank you for reading this letter.

Young Person Assent Form

Please read the following sheet very carefully.

Please put your initials in each box if you agree with each statement.

1. I have read and understand the information sheet for this study. I have been able to think about the information and ask any questions. I understand the answers to all questions that I had. ☐

2. I understand that taking part in this study is my choice. I am free to change my mind at any time, without giving any reason. ☐

3. I understand that if I decided not to continue taking part in the study anymore, I will be asked for the information collected from me up until that point can be included in the study. ☐

4. I agree to take part in the study. ☐

Name of Participant

_____

Date _____ Signature

_____

Name of Researcher

_____

Date _____ Signature

_____

Appendix H

CHOCI-R scoring and equivalence (Uher, Heyman, Turner and Shafran, 9th October 2007)

CHOCI-R scoring

CHOCI-R is a valid self-report and parent report measure of OCD severity. It has been used and validated in young people aged 9-17. Parent and child should complete their versions of the CHOCI-R independently of each other.

To obtain the total severity score, add up all 12 items on the 2 interference sections (six items for obsessions and six items for compulsions). The maximum score would be 48.

For the self-report version, 0-11 is sub-clinical; 12-23 is mild; 24-37 is moderate and 38 or more is severe OCD. For the parent version, the equivalent scores are a few points higher as parents appear to rate their children more severely. (see the Equivalent Score Table on the next page).

The table on the next page gives equivalent total scores of CHOCI-R self-report, CHOCI-R parent report and CY-BOCS (Child Yale-Brown Obsessive Compulsive Scales).

CHOCI-R References:

Shafran R, Frampton I, Heyman I, Reynolds M, Teachman B, Rachman S. The preliminary development of a new self-report measure for OCD in young people. Journal of Adolescence 2003; 26:137-142.

(development and preliminary validation of CHOCI)

Uher R, Heyman I, Turner C, Shafran R: Self-report, parent-report and interview measures of obsessive-compulsive disorder in children and adolescents. Journal of Anxiety Disorders, in press (accepted for publication 5/10/2007).

(validation of CHOCI-R and establishing equivalence with CY-BOCS)

Further Information:

If you have any questions regarding the use of the CHOCI-R, please contact Rudolf Uher at r.uher@iop.kcl.ac.uk

CHOCI-R scoring and equivalence; Uher, Heyman, Turner and Shafran, 9th October 2007

CHOCI-R-report	CHOCI-R-pare report
0	0-3
1	4
2	5-6
3-4	7
5	8-9
6	10
7	11-12
8-9	13
10	14
11	15
12	16-17
13	18
14-15	19-20
16	21
17	21
18	22
19	23
20	24
21	25
22	26
23	27
24	28-29
25	30
26	30
27	31
28	32

29	33	23
30	34	24
31	35	24
32	35	25
33	36	26
34	37	26
35	38-39	27
36	39	28
37	40	29
38	41	30
39	42	31
40	42	32
41-	43	33
43	44	34
44	45	35
45	46	36
46	47	37
47	48	38
48	48	39-

Appendix I

Cluster analysis between the EF subtests and the long version of parent rated CHOCHI-R

In this level of analysis, all the EF subtest except the Inhibition-Naming (INN) and Inhibition-Inhibition (INI) were loaded together with the total score of the long version of parent rated CHOCHI-R. Figure 1 shows ClustanGraphics dendogram illustrating sseven cluster solutions. Table 1 shows mean cluster scores for EF subtest and OCD and Figure 2 shows MDS scaling which illustrates cluster members in relations to anxiety.

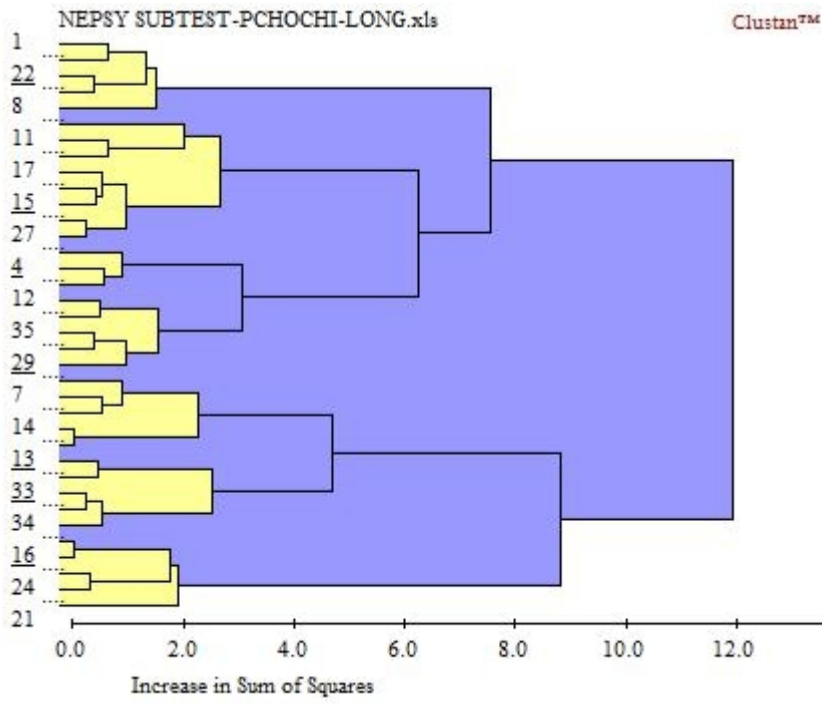


Figure 1.

ClustanGraphics dendogram illustrating significant five cluster solutions (cluster analysis 3).

Table 1.

Mean cluster scores for EF subtest and OCD symptoms.

Cluster	N	AS	AA	RS	CL	DF	INS	PCHOCHI
		score	score	score	score	score	score	score
1	5	7.40**	12.40	12.40	14.60	11.00	10.40	27.25*
2	8	4.25**	7.63**	10.63	9.88	8.38	12.25	36.71*
3	3	5.00**	7.33**	7.00**	13.67	2.67**	11.33	27.33*
4	5	5.20**	5.40**	9.80	13.00	5.80**	2.80**	30.40*
5	5	7.75**	4.50**	10.25	3.50**	5.50**	9.25	23.40
6	5	5.00**	3.00**	3.00**	4.40**	7.00**	11.20	27.20*
7	5	3.80**	13.75	12.25	4.75**	10.00	10.67	22.80

**Indicative of moderate OCD*

***Indicative of low EF performance (below expected level)*

Description of clusters

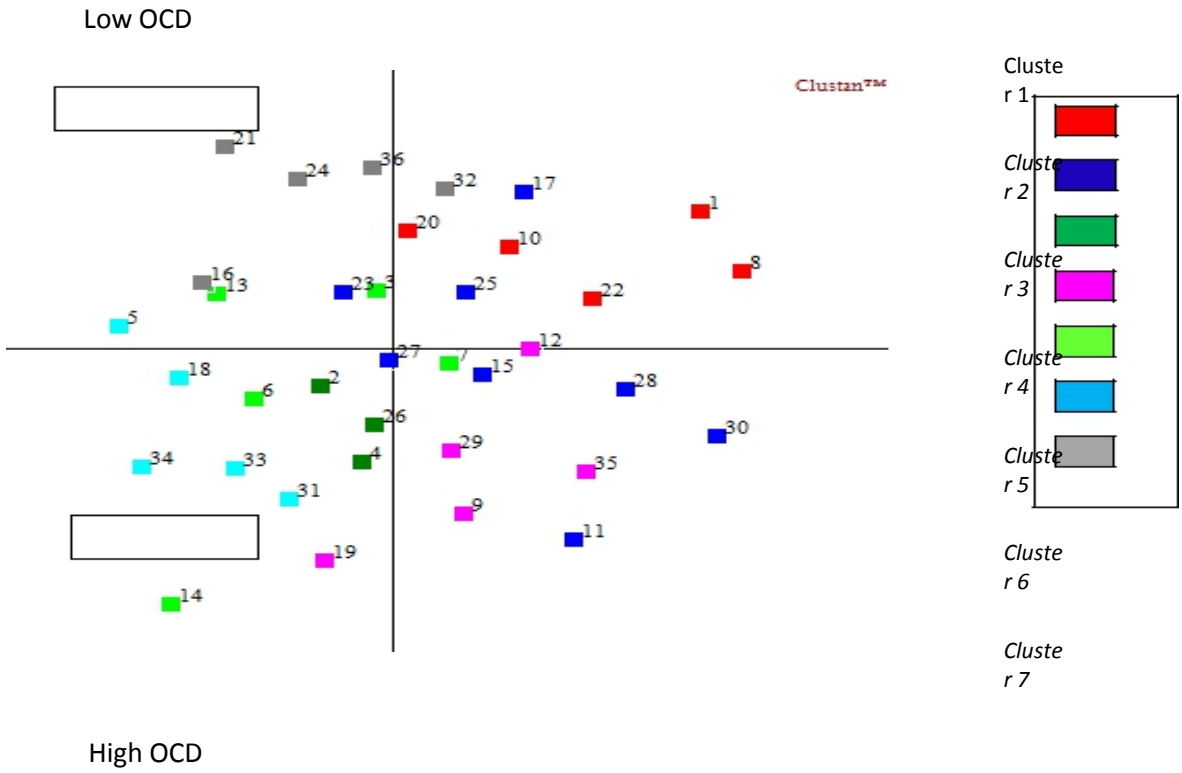


Figure 2.

ClustanMDS illustrates cluster members in relations to high and low of OCD scores.

Cluster 1: Children in cluster 1 (n=5) has moderate OCD and low AS subtest which indicates poor initiation, cognitive flexibility and self-monitoring.

Cluster 2: Cluster 2 represents eight children who demonstrate moderate OCD score and very low AS score. This suggest that these children has poor initiation, cognitive flexibility and self-monitoring.

Cluster 3: This cluster represents three children who show moderate OCD score and low AA and RS subtest. These children also have very low AS and DF subtest. This indicates that these children has poor selective and sustained attention as well as poor working memory. Low score on AS subtest indicates poor initiation, cognitive flexibility and self-monitoring, whereas very low score on DF subtest suggest impairment in initiation and productivity.

Cluster 4: The five children in this cluster have moderate OCD score, low AS, AA and DF subtests. They have the lowest INS subtest and at below expected level. This indicates that they have poor initiation, cognitive flexibility, self-monitoring, selective and sustained attention and impaired initiation and productivity as well as inhibition.

Cluster 5: This cluster represents by five children who have mild OCD score and poor AS, AA, CL and DF subtests. They are having the lowest CL subtest. This indicates that they have poor initiation, cognitive flexibility, self-monitoring, selective and sustained attention, planning and organizations ability and impaired initiation and productivity.

Cluster 6: This cluster represents by five children who have moderate OCD and low AS, AA, RS and CL subtest. They have the lowest AA and RS subtests. Low score in this subtest indicates that they have poor initiation, cognitive flexibility and self-monitoring, selective and sustained attention, working memory, planning and organizations abilities.

Cluster 7: This cluster represents by five children who have mild OCD score and poor AS, AA, CL and DF subtests. They are having the lowest CL subtest.

This indicates that they have poor initiation, cognitive flexibility, self-monitoring, selective and sustained attention, planning and organizations ability and impaired initiation and productivity.

Overall interpretations

Children in cluster 1, 2, 3, 4 and 6 have moderate OCD and associated with low AS subtest in all the clusters. This suggest that the presence of OCD symptoms in this group of children is characterized by poor initiation, cognitive flexibility and self-monitoring. Another subtest that is consistently impaired is AA subtest (cluster 2, 3, 4 and 6). Impairment in this subtest is indicative of poor selective and sustained attention abilities. Another EF subtest that is consistently impaired in relations to the presence of OCD symptoms is DF (cluster 3, 4 and 6). This further suggests that OCD symptoms in Children with OCD is characterized also by impairments in initiation and productivity abilities.

Appendix J

Ethical Approval for Study 2

28/10/14
Nooraini Darus
PhD Student and Principal Investigator
Institute of Neuroscience
School of Medical Sciences

Faculty of Medical Sciences
Newcastle University
The Medical School
Framlington Place
Newcastle upon Tyne
NE2 4HH United Kingdom

FACULTY OF MEDICAL SCIENCES: ETHICS COMMITTEE

Dear Nooraini,

Title: Anxiety in Autism Spectrum Disorders (ASD): The Influence of Executive Dysfunctions and Restricted, Repetitive Behaviours (RRBs)
Application No: 00817
Start date to end date: 22/10/14 to 30/01/2015

On behalf of the Faculty of Medical Sciences Ethics Committee, I am writing to confirm that the ethical aspects of your proposal have been considered and your study has been given ethical approval.

The approval is limited to this project: **00817/2014**. If you wish for a further approval to extend this project, please submit a re-application to the FMS Ethics Committee and this will be considered.

During the course of your research project you may find it necessary to revise your protocol. Substantial changes in methodology, or changes that impact on the interface between the researcher and the participants must be considered by the FMS Ethics Committee, prior to implementation.*

At the close of your research project, please report any adverse events that have occurred and the actions that were taken to the FMS Ethics Committee.*

Best wishes,

Yours sincerely

K. Sutherland,

Kimberley Sutherland
On behalf of Faculty Ethics Committee

cc.
Professor Andy Hall, Chair of FMS Ethics Committee
Ms Lois Neal, Assistant Registrar (Research Strategy)

*Please refer to the latest guidance available on the internal Newcastle web-site.

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Appendix K

Parental Information Sheet for follow up study (study 2)

Parental information sheet for follow up study

Exploring Executive Functions, Sensory Processing and Anxiety in Young people with Autism Spectrum Disorder (ASD) Phase Two

You are invited to take part in a research study. Before you decide to take part it is important for you to understand why the study is being done and what it involves. Please take time to read the following information carefully and discuss it with others if you wish. Please contact us if there is anything that is not clear or if you would like some more information.

What is the project about?

You may remember that you and your child kindly helped us with the first phase of our study. We have now collected information from all families. We would like to invite you to take part in the second part of the study. **This part will only involve parents.** We will not ask to see your child again. We are asking parents if they would help us to further understand some of the issues we asked you about in phase one. We will do this by asking you to complete some short questionnaires.

Why have we been invited to take part?

You have been asked to take part because you kindly helped us with part one of the study.

Do we have to take part?

Taking part in this study is entirely voluntary. It is up to you to choose whether to take part. If you do decide to take part, you can withdraw from the study at any time without giving a reason.

What will happen if I take part?

If you decide to take part we will ask you to sign a consent form, complete all the questionnaires and send them back to us in the stamped addressed envelope.

What would be involved?

We will ask you to fill in some questionnaires.

1. The Spence Children's Anxiety Scale, requires you to report on your child's feelings related to anxiety. It normally takes around 10 minutes to answer the questions.
2. The Behaviour Rating Inventory of Executive Function asks you to report on your child's thinking style on a day to day basis. It takes around 10 minutes to complete.
3. The Repetitive Behaviours Questionnaire asks you to report on your child's repetitive behaviours and takes around 10 minutes to answer.

   A demographic questionnaire which asks you to report on any major life events or treatment your child may have received since the last time we saw you. This takes around 5 minutes to complete.

Will my taking part in this study be kept confidential?

You will not be personally identifiable in the final report of this study. The questionnaires will not be looked at by anyone other than the research team. All the returned questionnaires will be stored securely in locked premises. All information about you will be handled in confidence.

Who is organising and funding the research?

This research is being funded by Newcastle University, United Kingdom.

Who has reviewed the study?

The study has been reviewed and approved by Newcastle University, Research Ethics Committee.

Can I talk to someone before agreeing to take part?

If you would like to further information about this project you can contact Dr Jacqui Rodgers on 0191 208 7562, Jacqui.rodgers@ncl.ac.uk. You are welcome to ask us any questions or discuss any worries you may have.

Thank you for reading this information sheet

Appendix L

Consent form for study 2

Consent for Participation in Follow up study

Exploring Executive Functions, Sensory Processing and Anxiety in Young people with Autism Spectrum Disorder (ASD)

Parent name: ……

1. **Have you read the information sheet?Yes ☐ No ☐**
2. **Have you had an opportunity to ask questions about the study?**

   Yes ☐ No ☐
3. **Have you received enough information about the study?**

   Yes ☐ No ☐
4. **Do you understand that you are free to withdraw from the study at any time, without having to give a reason, and that this will not affect the care of your child?**

   Yes ☐ No ☐
5. **Do you agree to filling in some questionnaires about your child's anxiety, thinking style and repetitive behaviour?**

   Yes ☐ No ☐
6. **Do you agree to anonymised information obtained in the study potentially being used in future research studies?**

   Yes ☐ No ☐

Signature of parent:…… Date:……..

Signature of researcher:…… Date:……..