Doctoral Thesis

Can training paradigms enhance global processing style in people with Asperger Syndrome? A randomised experiment

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Abstract

Background and Aims: The Weak Central Coherence Theory (WCCT; Frith & Happé, 1994) has been developed to explain the local processing bias observed in people with autism. The two aims of the thesis are: 1) to investigate whether adults with Asperger syndrome have a local processing bias, and 2) to investigate whether a local processing bias can be modified for people with Asperger syndrome using a computerised training paradigm.

Methodology: A 2 (Group: Asperger syndrome or typically developing) x 2 (Training: attentional control or intervention) x (2 (Time: 1 or 2) mixed experimental design *x S*) was used. Forty participants were randomised to the intervention or attention control condition. Both local and global processing style was assessed at pre- and post-test. A computerised global training paradigm was used to train "seeing the bigger picture". Training and test materials utilised the Navon Figures, which are large letters (global format e.g., an "H") made up of smaller letters (local format, e.g., smaller "F's").

Results: No significant difference between processing styles were found between those with Asperger syndrome and typically developing adults for local processing, t (37) = .46, p =.65 (two tailed), or global processing, t (38) = .81, p = .43 (two tailed), when naming local or global letters that have a differing letter at both the local and global level. Considering the main effect of training on global processing, those who received training scored significantly higher than those in the attention control condition at post-test (F(3, 36) = 10.738, p = .002, η^2 = 0.235), meaning that the training group took significantly longer to respond to the global stimuli, while those receiving the attention control condition

responded significantly faster. Ignoring training, typically developing adults took significantly longer at post-test to respond to global stimuli than those with Asperger syndrome ($F(3, 36) = 4.860$, $p = .034$, $\eta^2 = 0.122$). For local processing, no significant differences were found between those receiving training or those receiving attentional control conditions ($F(3, 35) = 2.313$, $p = .138$, $\eta^2 = 0.064$), or between people with or without Asperger syndrome ($F(3, 35) = .122$, $p = .729$, $\eta^2 = 0.004$).

Conclusions: The results do not support the WCCT (Frith & Happé, 1994) hypothesis of a local processing bias in Asperger syndrome. Similarly, the findings challenge the notion that people with Asperger syndrome have impaired ability to integrate local elements into a coherent whole (global processing). In essence, people with Asperger syndrome could ‘‘see the bigger picture’’ and demonstrated being equipped to employ either a global or local orientated search strategy. Considering that the attention control condition led to significant improvements in response times, training paradigms that involve repeatedly switching between processing styles may be advantageous because they could be arguably more representative of everyday processing. However, it is possible that these results are due to superior emotional inhibition and sustained attention abilities that people with Asperger syndrome are proposed to possess (Gonzalez, Best, Healy, Bourne, & Kole, 2010). A further extension of the research could track changes in processing style, achieved via a computer paradigm, to associated changes in observed everyday atypical behaviour by individuals with Asperger syndrome.

Chapter One

Introduction

1.1 Introduction to the Study

This chapter will begin with an overview of the thesis. It will then provide a background to Autism Spectrum Disorders (ASD) and Asperger syndrome. Information processing theories are then presented, followed by a systematic review of the literature investigating the Weak Central Coherence Theory (WCCT), which suggests a local processing bias for people with Asperger syndrome. Difficulties within the current body of literature will be considered, leading to an explanation of the aims of this study and the research questions.

1.1.1 Overview of the Thesis. The thesis is structured into four chapters. Chapter One provides a background summary of the relevant literature exploring local processing bias and reduced global processing by people with Asperger syndrome. The study aims and research questions are then described.

Chapter Two outlines the methodology used to answer the research questions. It describes the details of the design, participants, measures used, and procedures undertaken. Consideration is also given to ethical issues relevant to undertaking the study.

Chapter Three is a presentation of the results. Inferential statistics are used to answer the research questions described in Chapter One.

In Chapter Four, the results of the study are discussed in relation to the original research questions and background literature. The methodological,

theoretical and clinical implications of the research are discussed and emergent ideas for future research will be considered.

1.2 Autism Spectrum Disorders (ASD)

The earliest known reference to autism comes from the papers of Leo Kanner, who in 1938 recognised a pattern of behaviours to be common in a group of children. In his 1943 paper, Kanner described this pattern of behaviour as *early infantile autism* and crucially within diagnostic criteria indicated the pattern of behaviours needed to be present from birth to thirty months of age. Although for subsequent years the terms *childhood psychosis and childhood schizophrenia* were used as synonyms for *early infantile autism*, despite autism having consistent deficits in social functioning rather than a progressive deterioration of social functioning. The initial views about the origins of autism were controversial and described as caused by 'refrigerator mothers' who were unable to provide emotional warmth for their child. Subsequently, clinical research has provided little or no evidence to substantiate that 'refrigerator mothers' (or indeed fathers) caused autism (Wing, 1997). If a parent of an affected child appeared detached it is possible that they too have traits of autism or have adapted this parenting style as a response to caring for a child with autism (Wing, 1997).

From Kanner's (1943) observation of children he described the core diagnostic features of autism. Children with autism were typified by a lack of social responsiveness, the onset of which was considered to be very early in life. In addition to preferring to be alone, the child would also thrive on consistency and routine but to the detriment of finding change difficult. A repetitive

behavioural preference was also observed when children with autism manipulated objects, which was coupled with impairments in imaginative or creative uses for objects. Kanner (1943) also noted that children with autism had a good rote memory and could appear intelligent, although may be perceived as being unwilling rather than unable to apply their intellect. Another noted feature of autism was various sensory needs. Kanner detailed oversensitivity to loud noises and even food fads. When communicating, it was observed that children with autism presented with communication delays, difficulties applying language beyond their immediate needs and could even be mute. Subsequent observations of children led Kanner (1946) to suggest children with autism have a literal understanding and use of language. The later work by Kanner and Eisenberg (1956) incorporated concepts drawn from attachment theory (Bowlby, 1969) and moved towards a broader definition of autism as a condition rather than a description of behaviours. The defining characteristics remained an isolated individual, an insistent desire for sameness and communication impairments all evident within the first two years of life (Kanner & Eisenberg, 1956).

Working almost at the same time as Kanner (1943), Hans Asperger (1944) also observed behavioural features in children and described these as having Asperger syndrome. Unfortunately, the work of Asperger (1944) remained relatively unknown until its translation into English by Frith (1991a). As previously noted, many of the defining features of autism are present for people with Asperger syndrome, but with the distinction of have unimpaired or even superior intellectual ability. Though, it remains that many people with Asperger syndrome face challenges in many social, emotional, occupational and

educational contexts (Howlin, 2004). Difficulties faced by people with Asperger syndrome are often related to rigid routines and a preoccupation with specific details (Hill & Frith, 2003), which in turn may be related to information processing styles.

Over subsequent years the diagnostic criteria for Asperger syndrome has been reformulated to include: delayed speech and language development, impairments in forming interpersonal relationships, ritualistic behaviour and onset before 30 months (Rutter, 1970). These revisions formed the basis of the diagnostic criteria accepted by the World Health Organisation (1993) and American Psychiatric Association (1994). The next section describes the most widely used diagnostic criteria within autistic spectrum disorders, including Asperger syndrome.

1.2.1 Diagnostic Criteria. Autism is a neurological and developmental disorder characterised by an impairment in reciprocal social interaction and communication (verbal and nonverbal), combined with restricted interests and rigid and repetitive behaviours, all present from early childhood (American Psychiatric Association, 2000; World Health Organisation, 1993). Autism is one of five disorders within the classification of pervasive developmental disorders (PDDs), often referred to as autistic spectrum disorders (ASD; Evans & Morris, 2011).

Until recently, the diagnostic criteria for autism considered a triad of developmental impairments associated with social impairment, affecting thought and behaviour (Wing, 1996). Wing and Gould (1979) devised ‘the triad’ as represented by a restriction in the three domains of reciprocal social interaction,

communication (verbal and nonverbal) and social imagination. Wing and Gould (1979) suggests 'the triad' is reflected in a limited repertoire of behaviour and ritualistic behaviours seen in people with autism. Some of these characteristics may not be in keeping with Kanner's (1943) original description of autism, but do fall within the 'The Autistic Continuum' (Wing, 1988), later described by Wing (1996) as the 'Autistic Spectrum'. The 'Autistic Spectrum' assumes that social effectiveness is normally distributed within the general population. As such, the majority of people display average social abilities whilst few people exhibit extremely high or low levels of social effectiveness. However, the varying levels of social effectiveness are not distinct but blend into one another, and consequentially form a spectrum. One such 'spectrum disorder', Asperger syndrome, as originally described by Hans Asperger (1944), shares many of the 'core' diagnostic features of autism.

The diagnosis of Asperger syndrome did not appear until it was introduced by Wing (1981) in an attempt to distinguish between withdrawn and more able people with autism. Wing described the same core diagnostic features for Asperger syndrome as for people with high functioning autism, thus inferring the difference between autism and Asperger syndrome is based on severity of symptoms alone. The notion of severity of symptoms being a defining feature for Asperger syndrome had led to many researchers and clinicians challenging the need for a separate subgroup within the diagnostic criteria for autism (Volkmar, Cohen, Bregman, Hooks, & Stevenson, 1989). By the 1990s, consensus emerged and both major classification systems had adopted Asperger syndrome as a separate diagnostic construct (American Psychiatric Association,

1994; World Health Organisation, 1993). Both major diagnostic classification systems described Asperger syndrome as an impairment, which has not been universally accepted, with Happé (1999) arguing the construct should instead be viewed as a difference in cognitive style, rather than a deficit. Attwood (1998) appeared to support the non-pathologising of Asperger syndrome by referring to non-autistic people as 'neuro-typical' instead of 'normal'.

When describing Asperger syndrome, Hans Asperger (1944) suggested the condition could be distinguished from autism as individuals have unimpaired cognitive ability. The level of diagnostic agreement about the level of intellectual functioning in Asperger syndrome is variable. At one extreme some classification systems do not mention level of cognitive ability as a factor in diagnosing Asperger syndrome (Gillberg & Gillberg, 1989). Conversely, the two international classification systems of the Diagnostic and Statistical Manual of mental disorders, 4th Edition (DSM-IV) (American Psychiatric Association, 2000) and the International Classification of Diseases (ICD-10) (World Health Organisation, 1993), stipulate that the person should not have an intellectual disability in order to meet the diagnostic criteria of Asperger syndrome. Although, the level of clarity in the diagnostic criteria for Asperger syndrome permits it to be distinguishable from other similar diagnostic constructs on the autistic spectrum; namely autism, atypical autism and pervasive developmental disorder not otherwise specified.

The most recent version of the DSM-5 (American Psychiatric Association, 2013) revised the classification system for autism and subsequently Asperger syndrome no longer forms a separate diagnostic category. The revision

within DSM-5 (2013) positions autistic spectrum conditions as falling upon a continuum, subsequently adopting a dimensional model for classification with varying levels of symptom severity in two core domains within a single disorder. The revised classification system includes the diagnostic criteria formerly included as Asperger syndrome (DSM-IV), but incorporates a gradual transition from a 'neuro-typical' presentation, through to a presentation similar to Asperger syndrome, progressing to a profound autistic spectrum disorder presentation. The DSM-5 (2013) outlines autistic spectrum disorder as being characterised by: deficits in social communication and social interaction, and restricted repetitive behaviours, interests and activities. Rather than 'the triad', both components are required for a diagnosis of autistic spectrum disorder in accordance with DSM-5 (2013). Conversely, the World Health Organisation (1993) continues to adopt Asperger syndrome as a diagnostic category of autism, bearing in mind that a revision is due next year. However, within this study, the term Asperger syndrome is used, as participants were diagnosed with Asperger syndrome well before the advent of DSM-V.

1.2.2 Epidemiology. As little as 30 years ago autism was considered rare (4 in 10,000; Rutter, 1978), while more recent estimates indicate that it is more commonplace (1 in 100 and 6 in 1,000; Baron-Cohen, 2008 and Wing, 1996), with the prevalence being four times greater for men (Center for Disease Control and Prevention, 2010). The increased prevalence can be attributed to better recognition and diagnosis, and may lead to more people having their needs supported (Baron-Cohen, 2008). The argument, however, is not quite straightforward as there has been a lack of diagnostic consensus for Asperger

syndrome which has implications for our understanding of prevalence rates (Tantam, 2012). For example, in a large scale study, using four different diagnostic criteria, there was good concordance between prevalence rates using DSM-IV criteria (1 in 400), ICD-10 (1 in 370), and Gillberg and Gillberg (1989) criteria (1 in 345). However, the fourth criteria developed by Szatmari et al., (2007) provided prevalence rates out of kilter with the other classification systems (1 in 625). While there appears to be some consensus amongst some diagnostic classification systems, the remaining difficulties, coupled with the revision of DSM-5 (2013), attempting to report the prevalence of the syndrome within the general population is problematic (Fombonne, Zakarian, Bennett, Meng, McClean-Heywood, 2006).

Within the literature there appears to be some inconsistency when reporting the ratio of men and women diagnosed with Asperger syndrome. Historically the ratio of male to females with Asperger syndrome has changed over time. Previously, Gillberg (1989) used clinical experience to estimate that the male to female ratio for Asperger syndrome was 10:1, but others suggested it was as low as 4:1 when reviewing their clinical assessments (Attwood, 2007). There are a range of possible explanations for the differences across studies, 1) the differing methods used to collect data may be responsible for disparities in gender ratio figures reported, 2) challenges faced with Asperger syndrome as a diagnostic construct, 3) widening of the diagnostic criteria for Asperger syndrome narrows the prevalence ratio between males and females (Balfe, Tantam, & Campbell, 2011), 4) women with Asperger syndrome may just be better at assimilating in life despite their difficulties (Liptak, et al., 2008), 5)

specific interests for females may not be as idiosyncratic or eccentric as for some boys, 6) motor coordination for females may not be as conspicuous as for boys, and 7) historically women may have been less likely to seek help or referral for a diagnosis (Attwood, 2007). It is important to highlight that reviews of epidemiological studies would conclude that many symptoms of autism and Asperger syndrome are not specific or mutually exclusive to autism, making inferences about prevalence and gender ratios even more problematic (Wing & Wing, 1991).

1.2.3 Summary. The previous section has provided a description of autism and Asperger syndrome. It can be observed that a number of diagnostic challenges have been evident, and still remain, for autism and Asperger syndrome.

The next section will consider key information processing theories that were used to inform the development of this study. The psychological accounts of Asperger syndrome covered will seek to account for the behavioural features of the construct in terms of the underlying cognitive functions for such individuals.

1.3 Theories of information processing in Asperger syndrome

1.3.1 Central Coherence. One information processing theory relevant to people with Asperger syndrome, which may help understand some of the difficulties they encounter, is the theory of central coherence. This refers to the tendency for typically developing (TD) individuals to process information in a global context, often at the expense of local details (Frith, 1989), while people

with Asperger syndrome present with a local bias in processing (weak central coherence), at the detriment of processing more global or gestalt contextual information (strong central coherence; Frith & Happé, 1994). Although not explicitly included within the diagnostic criteria for Asperger syndrome, unusual perceptual processing styles have been characterised as common for this group.

1.3.2 Weak Central Coherence Theory. The ways that people with Asperger syndrome process information may help explain difficulties in social and occupational activities (Frith & Happé, 1994). People with autism are said to focus on the finer details, rather than understand the bigger picture, when processing information (Happé, 1999). A single theory of information processing style, the Weak Central Coherence Theory (WCCT), has been put forward which could explain why people with Asperger syndrome experience difficulties processing information across various life domains (Frith & Happé, 1994). The WCCT suggests that people with Asperger syndrome have a local processing bias which leads to focusing on finer details or on piecemeal bits of information (Happé & Frith, 2006) in comparison to typically developing individuals who are able to process information in its wider context (Hill & Frith, 2003). People with Asperger syndrome may demonstrate superior abilities at processing fine details (Happé, 1999) but often at the expense of processing, or integrating this with contextual or global information (Frith, 1989). Consequently, the WCCT (Happé & Frith, 2006) suggests a detail-focused local processing style in Asperger syndrome, arising from difficulties integrating pieces of information into a coherent whole (Frith & Happé, 1994). Thus, the theory stated that people with Asperger syndrome possess deficits in global

processing, and in fact the WCCT originally suggested an absence of global processing altogether. The latest refinements to the theory emphasise the notion of reduced global integration of information in Asperger syndrome (Happé & Booth, 2008). Theoretically for people with Asperger syndrome, the WCCT explains impairments in any task or real situation as being due to a failure to integrate information into a coherent whole (Jolliffe & Baron-Cohen, 2001a).

The WCCT originally proposed that local and global processing formed part of a continuum (Happé & Booth, 2008), with superior performance in one creating a deficit in the other. As evidence emerged that people with Asperger syndrome do engage in some global processing in some contexts (Nakano et al., 2012; Plaisted, O'Riordan & Baron-Cohen, 1998; Rondan & Deruelle, 2007) the WCCT was revised accordingly. Subsequently, Happé and Frith (2006) proposed that local processing bias was a dominant cognitive style in Asperger syndrome, which can be overridden if tasks explicitly require global processing. More recently, Katagiri, Kasai, Kamio, and Murohashi (2013) argued that global and local processing involves independent mechanisms, rather than being part of a continuum (Happé & Booth, 2008). Thus, if augmenting global processing in Asperger syndrome becomes viable, it could be achievable without any detrimental effects to local processing superiority.

The theoretical revision to the WCCT helps clinicians to conceptualise how people with Asperger syndrome understand information. The WCCT offers insight into difficulties with language in social communication (Jarrold, Butler, Cottington, & Jimenez, 2000), which often involves auditory and visual processing. If small pieces of verbal and nonverbal information cannot be

integrated with contextual information then understanding "gist" becomes problematic (Jolliffe & Baron Cohen, 1999). The difficulties people with Asperger syndrome have when interpreting language within context can be understood within the context of the WCCT as this explains the fixation on individual details of communication, literal interpretations and displays of contextually inappropriate behaviour (Jolliffe & Baron-Cohen, 2000).

1.3.3 Executive dysfunction theory. Executive function is defined as the ability to control action, and predominately, is thought to be associated with the frontal lobe of the brain. Action may take the form of deliberate motor movements, attention or thoughts. Action control requires the creation of plans, executing those plans, adhering to the plan, drawing on adaptive skills and shifting of attention as required (Klin, Volkmar & Sparrow, 2000; Luria, 1966). Thus intact executive functioning represents the ability to initiate and stop actions, to monitor and change behaviour as needed, and to plan future behaviour when faced with novel tasks and situations. From this, we are able to anticipate outcomes and adapt to changing situations. It has been proposed that people with Asperger syndrome have difficulty planning actions and switching attention due to a disorder in executive control functions (Ozonoff, Pennington & Rogers, 1991b). Executive dysfunction has been associated with damage to or underdevelopment of the prefrontal cortex (Ozonoff, 1995).

Typically, in tests of executive functioning, such as the Tower of London test, people with Asperger syndrome are slower than typically developing controls (Hughes, Russell & Robbins, 1994). Thus, when people with Asperger syndrome show impairments in planning and shifting actions, the need for

compensatory repetitive behaviours become apparent (Baron-Cohen & Bolton, 1993). It has been noted that executive functioning impairment is not exclusive to Asperger syndrome, with other conditions such as attention deficit hyperactivity disorder, obsessive-compulsive disorders, schizophrenia and some dementias having comparative cognitive deficits (Klin et al., 2000). Attempts have also been made to differentiate the specific type of executive functioning impairment for people with Asperger syndrome. Ciesielski and Harris (1997) described that executive functioning deficits for people with Asperger syndrome specially relate to challenges in disengagement of a task in a set perceived way. The explanation of being unable to disengage in tasks would explain difficulties people with Asperger syndrome have in switching tasks or managing a change in routine (Katagiri, Kasai, Kamio, & Murohashi, 2013). However, this explanation ignores the content of the interests shown by people with Asperger syndrome and thus perceives them as random choices. Additionally, the evidence for the Executive Functioning theory remains limited and inconsistent. Even the Tower of London test has produced contradictory results (Baron-Cohen & Bolton, 1993).

1.3.4 Mindblindness theory. People with Asperger syndrome have delayed development of theory of mind (ToM), or Mindblindness as Baron-Cohen (1996) conceptualised this impairment. Theory of mind is the ability to understand that other people have thoughts, feelings and intentions, and in turn, an ability to decipher other's mental state according to their behaviour. Thus, intact theory of mind helps us to explain and predict others behaviours, by working out peoples intentions and interpreting interactions. Baron-Cohen

(1995) described the process of acquiring skills, enabling one to understand others have thoughts, feelings and intentions, suggesting that this occurs at the age of four years for typically developing children. Thus, with impairments in theory of mind, a person with Asperger syndrome may have difficulties empathising when another person's thoughts, feelings or intentions are different to their own (Gillberg, 1996). People with Asperger syndrome are proposed to literally lack the ability to think about others thoughts (Baron-Cohen, 1996).

A major strength of Mindblindness theory is that it makes sense of the social and communication difficulties people with Asperger syndrome experience. Thus, in principle, the theory could be universally applied to all people with Asperger syndrome in all social contexts. Conversely, the Mindblindness theory does not adequately account for non-social features of the syndrome, such as restricted interests. In addition to mind reading, empathy requires an emotional response to others state of mind. Many people with Asperger syndrome find it a challenge to respond to others state of mind. As noted for many constructs within Asperger syndrome, Mindblindness is not exclusive to this syndrome or autism, but is also found in other disorders; namely schizophrenia. But this is true of other impairments in Asperger syndrome; people with learning disabilities and selective mutism may have social communication developmental impairments, and both conditions can be confused with Asperger syndrome (Quinn & Malone, 2000).

1.3.5 Empathising-systemising theory (and by extension, the extreme male brain theory).

This theory emerged after Baron-Cohen (2009) observed the prevalence of autism to be greater in people studying physical

sciences, when compared to other subjects. From these observations it was hypothesised that there are two cognitive styles, 'systematising' and 'empathising' (Baron-Cohen, 2003). Systematising entails a drive to analyse and construct a system. People intuitively figure out the rules of a system and do so in order to understand a system and predicts its behaviour (Baron-Cohen, Knickmeyer, Belmonte, 2005). Once a system has been understood people can even create new ones. The second cognitive style, empathising, is also a drive but to identify and understand a person's emotions and respond to them. It entails more than just understanding how somebody thinks and feels, as it encompasses predicting people's behaviour in an attempt to emotionally connect with them (Baron-Cohen, 2003).

The empathising-systemising theory suggests that the discrepancy between empathising-systemising determines whether people are likely to develop Asperger syndrome (Baron-Cohen 2009). As part of the theory, men are considered to be better at systematising while women are better at empathising. The empathising-systemising theory then fits with the notion that autism spectrum disorders are caused by the extreme male brain (Baron-Cohen & Hammer, 1997). Thus, the extreme male brain theory postulates a cognitive style with superior abilities in systematising tendencies but delays and deficits in affective empathy (Baron-Cohen & Hammer, 1997).

The theory predicts that people with Asperger syndrome go deeper into the topic, and thus interests become narrower through the drive to find out all details about a topic (Baron-Cohen, 2009). The selection of such interests is not random as people with Asperger syndrome are drawn towards information that

can be systematised, and typically they become experts in particular areas of interest. Further, the theory also predicts that people with Asperger syndrome have preference for local processing but can see the whole, given time to do so (Baron-Cohen, 2009).

A major strength of the theory is that it explains both the social and non-social aspects of Asperger syndrome (Tantam, 2012). Low empathy explains the social communication difficulties, while systematising accounts for restricted interests, repetitive behaviours and difficulties in managing change (Baron-Cohen, 2009). When a person systematises, feeling safe and secure depends on the world remaining consistent and predictable. Patterns and sequences of behaviour are perceived as logical and security is drawn from behaviour being constant. The empathising-systemising theory would regard systematising as intelligent behaviour performed to make sense of the world (Baron-Cohen, 2009).

In accordance with the Empathising-Systematising theory (Baron-Cohen, 2009), Baron-Cohen, in collaboration with others, devised self-report measures for each respective construct. The Empathy Quotient (EQ; Baron-Cohen & Wheelwright, 2004) and Systemising Quotient (SQ; Baron-Cohen, Richler, Bisarya, Gurunathan, & Wheelwright, 2003) were devised to capture the cognitive and behavioural features of how people with autism process information. Despite developing such scales to measure empathising and systematising capabilities, little independent investigation appears to be present for each cognitive style. Contention also exists whether empathising and systematising merit simple descriptions as a cognitive style (Tantam, 2012), and

whether the constructs are specifically associated with autism. Auyeung et al., (2009) repeated the empathising and systematising surveys using parental ratings of their child rather than self-report. Results were consistent with males displaying higher systematising tendencies and females having higher empathising scores. Uncertainty remains, however, if increased systematising by people with autism is caused by increased testosterone levels, sexually dimorphic brain development, socialisation of gender roles or impairments in social interactions. People with autism have been described as potentially learning some social skills by rote learning, and achieving a learnt social intelligence through systematising.

1.4 Weak Central Coherence Theory in Asperger syndrome: a systematic literature review

The Weak Central Coherence Theory's (WCCT) account of information processing, for people with Asperger syndrome, provides the theoretical framework for the thesis. Since the inception of the WCCT, it has been important to establish if a systematic application of the theory has been employed in research. Otherwise, the theory is in danger of overextension to the real life situations it inadequately explains (Jolliffe & Baron-Cohen, 2001a). It is important to undertake testing of local processing and global information integration, in order to test the assumptions put forward within WCCT. Early research has yielded variable support for the WCCT, as some people with Asperger syndrome were shown to favour local details (Mottron & Belleville, 1993), while in the same task a preference for making use of global meaning was described (Ozonoff, Strayer, McMahon, & Filloux, 1994). As such, it is

appropriate to conduct a systematic review of the current research undertaken to support or challenge the theory. This section will present a review of the literature exploring the WCCT for adults with Asperger syndrome. The aims of the review are to explore the consistency of support for the WCCT across different modalities of information processing and using a variety of stimuli.

A systematic literature search was conducted using Medline, Cumulative Index to Nursing and Allied Health Literature (CINAHL), PsychINFO and Embase databases. The search was performed on the 15th April 2014 for the period of 1990 onwards: to include research predating the inclusion of Asperger syndrome as a form of autism within DSM-IV (APA, 1994) and ICD-10 (WHO, 1993). The key search terms and Boolean connectors were entered as follows:

1. adult* OR grown-up*
2. processing style* OR process*
3. autis* OR Asperger* OR pervasive developmental disorder*
4. Weak Central Coherence* OR WCC* OR Central Coherence*
5. 1 AND 2 AND 3 AND 4

1.4.1 Study Selection Criterion. Studies were included if:

a.) The paper reported original empirical research

b.) Focused on a sample who had been diagnosed with autism

c.) Participants were over the age of 18

d.) The paper tested local and global processing in accordance with the WCCT

e.) The study had a quantitative design

f.) The study did not use electrophysiological techniques

g.) Participants were without co-morbid schizophrenia

Additionally, to ensure selected papers had undergone empirical rigour case reports, reviews and unpublished observations were excluded from the search. Limitations were set on language (English) and publication date (1990-present). Furthermore, the ancestry method was used to screen for additional eligible studies.

1.4.2 Search Outcome. The initial search yielded 118 hits across the four databases, with four additional papers found using the ancestry method. After screening for duplications, in a pre-selection process, titles and abstracts were screened for relevance based on the aforementioned inclusion criteria. After applying the inclusion and exclusion criteria, a total of fifteen articles were included in the current review as detailed in Figure 1.

1.4.3 Data Extraction. Figure 1 describes the procedure, participant characteristics, outcome measures and results for the current review. A glossary for the acronyms used within Table 1 can be located in the *notes* section.

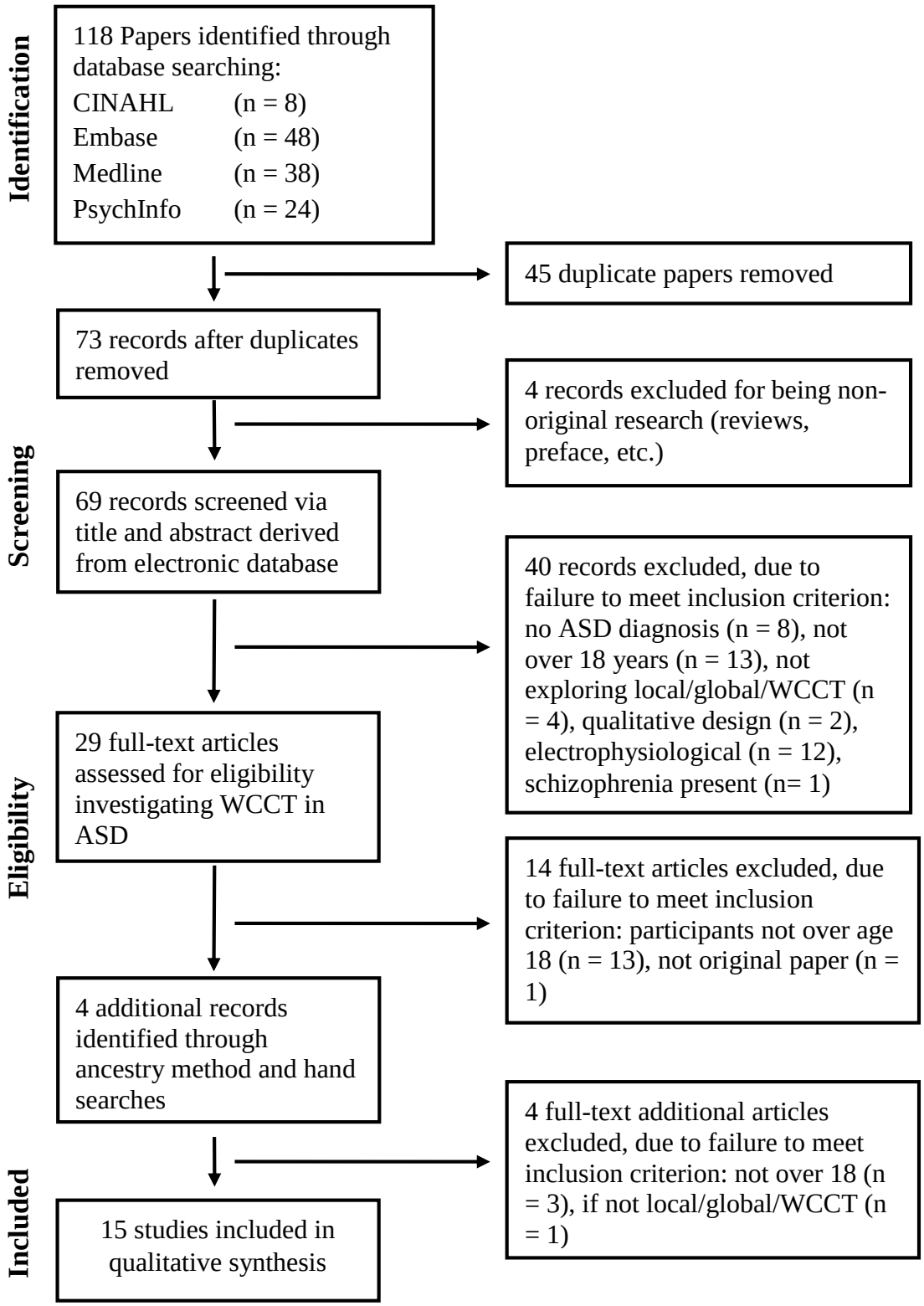

Figure 1. Summary of search procedure. From: PRISMA guidance, Moher et al. (2009).

Table 1. *Summary of studies exploring WCCT*

Study	Design/Procedure (all cross-sectional)	Participant Characteristics (all matched on age, gender and IQ)	Outcome Measures	Results and Conclusions
Barnes & Baron-Cohen (2012)	Between groups testing scene recall from the television show *House*	*n* = 28 AS/HFA *n* = 28 TD control (matched on writing ability) *M* age for groups 30.2 years	Scaled descriptive scores on characters, conflict, setting and resolution	A significant group difference, with local processing bias in AS and HFA for all four descriptive scales. Conclusions: Multi-modal processing provided strong support for the WCCT when recalling descriptive features of televisual social interactions
Behrmann et al. (2006)	Between groups testing facial recognition, local bias, and the correlation between prosopagnosia and global processing	*n* = 14 HFA (12 male and 2 female) *n* = 27 TD control (matched on education level) Age range 19 – 53 years, for both groups	Facial recognition Hierarchical Letters (HL; Navon, 1977) Microgenetic Prime Paradigm (Beller, 1971)	People with HFA displayed a local processing trend when processing HLs. Additionally, a significant correlation between object and facial recognition, with global processing, is indicative of enhanced local and reduced global processing in HFA. People with HFA were significantly slower but as accurate at facial recognition compared to people without HFA. Conclusions: With the exception of facial recognition accuracy the WCCT is supported in its entirety.

Table 1. *Summary of studies exploring WCCT*

Study	Design/Procedure (all cross-sectional)	Participant Characteristics (all matched on age, gender and IQ)	Outcome Measures	Results and Conclusions
Beversdorf et al. (1998)	Between groups testing emotion and context in recall	*n* = 10 HFA (7 male 3 and female) *M* age 30.8 years *n* = 13 TD control (8 male and 5 female) *M* age 30.6 years (Educational level significantly different between groups)	Audio coherence and memory recall Audio emotional and memory recall Audio Theory of Mind	No significant differences between groups when testing coherence versus incoherent audio recall. Emotional content aided recall more for controls, whilst memory impairments were influence by coherence for people with HFA. Conclusions: Impairments in emotional processing for people with HFA cannot sufficiently be explained by the WCCT.
Bölte, Holtmann, Poustka, Scheurich, & Schmidt (2007)	Between groups testing Gestalt perception using various novel stimuli	*n* = 15 HFA (15 male) *M* age 25.7 years *n* = 15 schizophrenia (15 male) *M* age 34.9 years *n* = 15 depression (15 male) *M* age 43.4 years *n* = 15 control (15 male) *M* age 27.0 years (Age differs significantly between groups and no female participants)	Visual illusion (Poppelreuter, 1917/1990) Block Deign (BD; Tewes, 1991) Embedded Figure Test (EFT; Witkin et al., 1971) Gestalt stimuli & HLs	Gestalt stimuli processed using finer details and reduced susceptibility to visual illusions by people with HFA. Also, significantly reduced use of context in processing. Negative correlation between EFT/BD scores and visual illusion susceptibility for people with HFA. But, HLs identification accuracy and processing was the same for all groups. Conclusions: HFA group had a local bias and reduced global processing for Gestalt stimuli, BD, EFT and visual illusions. HL's showed global processing ability for HFA.

Table 1. *Summary of studies exploring WCCT*

Study	Design/Procedure (all cross-sectional)	Participant Characteristics (all matched on age, gender and IQ)	Outcome Measures	Results and Conclusions
Jolliffe & Baron-Cohen (1997)	Between groups local processing tested using novel stimuli	*n* = 17 HFA (15 male and 2 female) Age range 19 – 46, *M* 30.71 years *n* = 17 AS (15 male and 2 female) Age range 18 – 49, *M* 27.77 years *n* = 17 control (15 male and 2 female) Age range 18 – 49, *M* 30.0 years (matched on handedness)	EFT testing accuracy and reaction time Rey Complex Figure Test (RCFT; Osterrieth, 1944)	ASD groups are significantly faster at the EFT, suggesting a local processing style. Although a local processing trend was evidenced by the RCFT, this was not significantly different between groups. Conclusion: Different novel stimuli demonstrated a local processing bias for people with HFA and AS.
Jolliffe & Baron-Cohen (1999)	Between groups testing contextual word interpretation via homograph test, local coherence test and ambiguous sentence test	*n* = 17 HFA (15 male and 2 female) Age range 19 – 46, *M* 30.71 years *n* = 17 AS (15 male and 2 female) Age range 18 – 49, *M* 27.77 years *n* = 17 control (15 male and 2 female) Age range 18 – 49, *M* 30.0 years (matched on handedness)	Homograph test Local coherence inference test Ambiguous sentence test	People with HFA and AS are significantly impaired using sentence context spontaneously, unlikely to use context-appropriate pronunciation, are unable to deduce gist, and do not use context when interpreting ambiguous sentences Conclusions: People with HFA and AS displayed a local processing bias and impaired global processing when performing contextual word interpretation.

Table 1. *Summary of studies exploring WCCT*

Study	Design/Procedure (all cross-sectional)	Participant Characteristics (all matched on age, gender and IQ)	Outcome Measures	Results and Conclusions
Jolliffe & Baron-Cohen (2000)	Between groups testing global coherence: coherent sentence arrangement and using context to make global interpretations	*n* = 17 HFA (15 male and 2 female) Age range 19 – 46, *M* 30.71 years *n* = 17 AS (15 male and 2 female) Age range 18 – 49, *M* 27.77 years *n* = 17 control (15 male and 2 female) Age range 18 – 49, *M* 30.0 years (matched on handedness)	Global integration test Global coherence test	People with HFA and AS have significant difficulty arranging sentences coherently and using contextual information. People with AS displayed the greatest deficits and thus a stronger local processing style. Conclusions: The WCCT's posited local processing bias and reduced global processing is upheld for people with AS and HFA when using global coherence tests.
Jolliffe & Baron-Cohen (2001a)	Between groups testing object integration, ability detecting similarities and processing objects out of context	*n* = 17 HFA (15 male and 2 female) Age range 19 – 46, *M* 30.71 years *n* = 17 AS (15 male and 2 female) Age range 18 – 49, *M* 27.77 years *n* = 17 control (15 male and 2 female) Age range 18 – 49, *M* 30.0 years (matched on handedness)	Object integration test Scenic test	The scenic and integrating objects tests showed people with HFA and AS naturally focused on fine details and not context. But clinical groups detected similarities and processed global information if directed to. Conclusion: A local processing style appears inherent for people with HFA and AS. But, they can process global information when explicitly asked to do so.

Table 1. *Summary of studies exploring WCCT*

Study	Design/Procedure (all cross-sectional)	Participant Characteristics (all matched on age, gender and IQ)	Outcome Measures	Results and Conclusions
Jolliffe & Baron-Cohen (2001b)	Between groups testing conceptual integration with fragmented objects	*n* = 17 HFA (15 male and 2 female) Age range 19 – 46, *M* 30.71 years *n* = 17 AS (15 male and 2 female) Age range 18 – 49, *M* 27.77 years *n* = 17 control (15 male and 2 female) Age range 18 – 49, *M* 30.0 years (matched on handedness)	Hooper Visual Organisation Test (Hooper, 1983)	People with HFA and AS had significantly impaired ability integrating pieces into a coherent whole. People with AS displayed the greatest deficits. Good object identification from a single object piece was intact for people with HFA and AS. Conclusions: People with HFA and AS have a local processing bias and reduced global processing, when tested using visual stimuli.
Katagiri, Kasai, Kamio & Murohashi (2013)	Between subjects repeated-level trials and within-subjects switching between local and global processing	*n* = 11 AS (3 male and 8 female) *M* age 31.1 years *n* = 11 TD control (3 male and 8 female) *M* age 28.3 years (matched on handedness)	HL switching tasks	When using HLs people with AS had significant difficulty switching from local to global processing. Conclusion: A local processing bias is evident for people with AS and consequently reduced global processing.
Katsyri, Saalasti, Tiippana , von Wendt, & Sams (2008)	Between-subjects factor group and within-subjects factors testing emotional recognition with static and dynamic facial expressions	*n* = 20 AS (13 male and 7 female) *M* age 32 years *n* = 20 TD control (13 male and 7 female) *M* age 31 years	Facial expression stimuli of anger, disgust, fear and happiness (Katsyri, 2006)	People with AS had intact recognition of basic emotions and dynamic facial features using local processing. But they were significantly impaired when processing complex global facial features. Conclusions: Enhanced local processing and reduced global processing was evident for people with AS in facial recognition tasks.

Table 1. *Summary of studies exploring WCCT*

Study	Design/Procedure (all cross-sectional)	Participant Characteristics (all matched on age, gender and IQ)	Outcome Measures	Results and Conclusions
Nakano, Kato & Kitazawa (2012)	Between-subjects factor of groups for shape perception tested by touch	*n* = 5 ASD and 9 AS (10 male and 4 female) *M* age 30.7 years *n* = 20 TD (15 male and 5 females) *M* age 27.6 years (Groups matched on handedness)	Touch-to-visual shape matching (orientation & length) Vandenberg Mental Rotation Test (Vandenberg & Kuse, 1978)	Both groups integrated piecemeal stimuli into a coherent whole using touch feedback for delayed visual shape matching. Conclusions – Both groups displayed global processing by integrating sensorimotor traces into a visual coherent whole.
Plaisted, O'Riordan & Baron-Cohen (1998)	Between-subjects factor testing discrimination of familiar and novel stimuli	*n* = 8 HFA (Gender ratio unknown) *M* age 28 years 9 months *n* = 10 TD controls *M* age 28 years 6 months	Perceptual learning task	People with HFA discriminated novel (local) stimuli significantly better than controls but had impaired global processing in discriminating familiar stimuli. Conclusions: Impairments using contextual (global) knowledge and enhanced local processing were observed for HFA group.

Table 1. *Summary of studies exploring WCCT*

Study	Design/Procedure (all cross-sectional)	Participant Characteristics (all matched on age, gender and IQ)	Outcome Measures	Results and Conclusions
Rondan & Deruelle (2007)	Between groups testing visual processing of novel stimuli and face-like geometric shapes	*n* = 21 AS and 5 HFA (23 male and 3 female) *M* age 26 years 2 months Age range 18 – 43 years *n* = 26 TD controls (23 male and 3 female) *M* age 27 years 8 months Age range 18 – 43 years	Hierarchical Figures & HLs Schematic faces and geometric face shape stimuli (Deruelle et al., 1999)	People with AS and HFA focused on details of face shapes, displaying a local processing bias. Although, global processing of HLs was evident by all groups. Conclusions: Despite people with AS and HFA demonstrating a local processing bias, it appears that global aspects of stimuli (HLs) can be processed.
Spek, Scholte& Van Berckelaer-Onnes (2011)	Between-groups testing local processing bias. Correlation between self-reporting and neuropsychology measures to be tested	*n* = 42 HFA (35 male and 7 female) *M* age 37.2 years *n* = 41 AS (37 male and 4 female) *M* age 41.3 years *n* = 41 TD control (30 male and 11 female) *M* age 39.3 years (Handedness matched between groups)	Autism Quotient - attention scale (Baron-Cohen et al., 2001) Systemizing Quotient (Baron-Cohen et al., 2003) BD (Wechsler, 1997) EFT	Self-report measures showed a significant local processing bias for people with HFA and AS. Neuropsychological tests showed no difference in local processing between groups. Only a weak correlation was reported between self-report and neuropsychological tests, which suggests unitary constructs were not present. Conclusions: Neuropsychological measures and self-reports may measure different constructs of information processing.

Note. ASD = Autism Spectrum Disorder, HFA = High-Functioning Autism, AS = Asperger Syndrome, IQ = Intelligence Quotient, TD = Typically Developing.

1.4.4 Visual information processing. To investigate the possibility of a local processing bias in individuals with Asperger syndrome, as proposed by the WCCT, many studies employed locally orientated novel tasks, such as the Embedded Figures Test (EFT; Witkin, Oltman, Raskin, & Karp, 1971; Jolliffe & Baron-Cohen, 1997; Bölte et al., 2007) which focuses on visual stimuli. When testing local processing bias in Asperger syndrome or high functioning autism, clinical groups were significantly faster than controls at the EFT (Jolliffe & Baron-Cohen, 1997) and other tasks testing perceptual learning (Plaisted et al., 1998). Not surprisingly, alternative visual locally orientated tasks, including Gestalt stimuli, provided further support for the WCCT (Bölte et al., 2007). On the whole, clinical groups produced a local processing bias as opposed to focusing on contextual information requiring a global processing style.

The Rey Complex Figure Test (RCFT; Osterrieth, 1944) was also used to explore local processing bias in adults with high functioning autism and Asperger syndrome (Jolliffe & Baron-Cohen, 1997). On the positively skewed RCFT (Jolliffe & Baron-Cohen, 1997) there was evidence of a local processing trend for the clinical groups but this was not significantly different to typically developing controls. As an extension to their original study, Jolliffe and Baron-Cohen (2001b) looked beyond examining stimuli in isolation by asking participants to integrate local features into a coherent whole. Jolliffe and Baron-Cohen (2001a, 2001b) then found that people with high functioning autism and Asperger syndrome displayed a significantly impaired ability to integrate information, including fragments of familiar and unfamiliar objects, into a coherent whole. Although this demonstrated a local processing bias for people with Asperger syndrome and high functioning autism, global processing was

possible when people were explicitly asked to do so (Jolliffe and Baron-Cohen, 2001b). The results require cautious interpretation because the fragmented stimuli could draw attention towards local features. It also remains unclear whether a local bias prevents access to pre-requisite contextual knowledge or whether the global features remain unprocessed.

Further support for the WCCT appeared to be dependent on the outcome measures used to test processing styles. Plaisted, O'Riordan and Baron-Cohen (1998) indicated weak central coherence was evident in people with high functioning autism only when testing perceptual learning with novel stimuli. Spek, Scholte and Van Berckelaer-Onnes (2011) found no significant local processing bias for people with Asperger syndrome using the block design task but did using self-report measures of visual processing (The Autism Spectrum Quotient; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubey, 2001 and Systemising Quotient; Baron-Cohen, Richler, Bisarya, Gurunathan, & Wheelwright, 2003). Additionally, Spek et al. (2011) reported the correlation between self-report measures and neuropsychology tests was a weak one. Potentially, self-report measures can be influenced by response bias (Hammond, 1995), while neuropsychology tests can be affected by ceiling effects masking group differences due to low variances (Clark-Carter, 2012).

The WCCT suggests that those with Asperger syndrome cannot see the "whole picture", which simply is not true (Baron-Cohen, 1993). Within the Navon (1977) hierarchical letter test, people with Asperger syndrome can see the bigger letters (Bölte et al., 2007; Rondan & Deruelle, 2007). Navon proposed evidence for a global-dominance processing model for typically developing

adults, which included a sequence starting at global processing and then focusing on finer (local) details. To test processing styles, Navon devised hierarchical constructed patterns, with larger figures (e.g., large letters) to test global processing, constructed from suitable arrangements of smaller figures (e.g., smaller letters). Larger and smaller letters can either be the same or different for each hierarchical letter. The bigger hierarchical letters are recognised by people with Asperger syndrome, which indicates the difficulty does not arise at the basic feature integration level (Rondan & Deruelle, 2007). Nor is there a binding problem preventing people seeing objects as objects rather than clusters of features (Jolliffe & Baron-Cohen, 2001). So, the impairment in global processing must occur at a higher level of processing, as yet to be clarified. The WCCT would benefit from clarifying whether the difficulty of integration of information into a coherent whole occurs at the attentive or perceptual level of information processing (Jolliffe & Baron-Cohen, 2001), and warrants further exploration.

Many studies have since used Navon (1977) hierarchical letters to investigate processing styles for individuals with Asperger syndrome, but with inconsistent results. Katagiri et al. (2013) reported a local processing bias for people with Asperger syndrome, while Behrmann et al. (2006) described the same processing bias for people with high functioning autism. Conversely, other studies reported people with Asperger syndrome demonstrated a preference for global processing (Bölte et al., 2007; Rondan & Deruelle, 2007). Hierarchical letters may evidence intact global processing in Asperger syndrome because, unlike most stimuli, the stimuli test both local and global processing.

The inconsistent results from using Navon-type stimuli, however, could be attributed to variations in construction and display of hierarchical letters (Wang, Mottron, Peng, Berthiaume, & Dawson, 2012). Han, Wang and Zhou (2004) demonstrated that when smaller letter density or grouping is altered a preference can be created towards local or global processing. Additionally, the results of the studies described are difficult to compare because of the varied exposure time of the hierarchical letters (Kimchi, 1992). Furthermore, when identifying hierarchical letters, and also the EFT noted earlier within this section, a forced-choice between two responses reduces the range of scores possible to participants. If measures are deemed to produce ceiling effects it potentially prevents significant differences in local processing being detected, as was possibly observed for Jolliffe and Baron-Cohen (1997). However, the use of hierarchical letters overcomes the problem of a small variance and increases the range of scores when measuring both reaction time and accuracy of responses.

Other studies providing evidence for the WCCT used alternative stimuli that arguably orientated attention towards finer details of tasks (Wang et al., 2012). Such tasks include the EFT (Jolliffe & Baron-Cohen, 1997; Bölte et al., 2007) or Block Design (Bölte et al., 2007; Spek et al., 2011) and debatably the demand characteristics of the task influences processing bias. The construct validity for the EFT and Block Design is questionable as neither was designed to assess local processing, although both are now frequently used for this purpose (Chaytor, Schimitter-Edgecombe, & Burt, 2006). Conversely, on other types of tasks requiring integration of visual stimuli, people with Asperger syndrome had significantly impaired ability to integrate objects into a coherent whole (Jolliffe & Baron-Cohen, 2001a, 2001b).

In summary, when processing visual stimuli, a local processing bias in Asperger syndrome and high functioning autism was generally observed, but the ability to undertake global processing appeared to be dependent on being directed to attend to global information and the type of information processed (Jolliffe & Baron-Cohen, 2001b).

1.4.5. Facial recognition processing. Facial recognition tasks were employed in three studies (Behrmann et al., 2006; Katsyri, Saalasti, Tiippana, von Wendt, & Sams, 2008; Rondan and Deruelle, 2007) and all supported the hypothesis that significant local processing bias exists for people with Asperger syndrome or high functioning autism. Rondan and Deruelle (2007) demonstrated a significant local processing bias when using schematic face shapes with people diagnosed with high functioning autism. While using photographic face stimuli, Behrmann et al. (2006) established facial recognition ability positively correlated with global processing, commensurate with significant impairments in global facial processing for people with Asperger syndrome (Katsyri et al., 2008). The studies of both Behrmann et al. and Rondan and Deruelle support the WCCT, and methodologies ensured differences between groups were controlled within baseline demographics (Roberts & Torgerson, 1999).

Subsequently, Katsyri et al. (2008) added to these findings, demonstrating significant impairments in global facial processing for people with Asperger syndrome. To investigate the WCCT, Katsyri et al. used ecologically-valid facial stimuli rather than abstract or constructed stimuli. Katsyri et al. evaluated facial emotional recognition, which was intact for individuals with Asperger syndrome when processing basic emotions but impaired for complicated emotions, the

latter viewed as requiring intact global processing. As facial recognition seemingly requires global processing, the WCCT would explain the high prevalence of prosopagnosia (impaired facial recognition) in individuals with Asperger syndrome and other variants of autism (Katsyri et al., 2008). Overall, the evidence indicates that facial recognition tasks have consistently supported the existence of a local processing bias and global impairments in Asperger syndrome.

1.4.6 Auditory information processing. Research using auditory stimuli, conducted by Beversdorf et al. (1998) indicated no significant difference in the processing styles used for verbal coherence tests between people with high functioning autism and typically developing groups. One possible explanation for the results could be that significant differences in education level and handedness between the clinical and control groups prevented differences in processing style from being detected. Contrastingly, Jolliffe & Baron-Cohen (1999 & 2000) did find support for the WCCT by showing impaired performance for Asperger syndrome and high functioning autism groups using contextual information to deduce meaning. However, since the turn of the century there is a paucity of studies investigating the WCCT using auditory processing stimuli.

1.4.7 Multimodal information processing. Particularly novel research by Nakano, Kato and Kitazawa (2012) coupled touch feedback to visually presented shapes. When testing multimodal processing, Nakano et al. (2012) observed similar global processing abilities for adults with and without Asperger syndrome. Additionally, adults with Asperger syndrome produced superior performance, when compared to typically developing adults, when touch-to-

visual shape matching. However, it remains questionable when touch-to-visual shape matching would be performed within everyday tasks. Subsequently, Barnes and Baron-Cohen (2012) coupled visual and auditory processing more typical of everyday information processing, using a television show. It is reasonable to suggest the televisual stimuli used offers a more ecologically valid representation of daily activities. From coupling visual and auditory processing, Barnes and Baron-Cohen (2012) described a clear local processing bias for adults with Asperger syndrome and high functioning autism. Generally, the use of multimodal processing appeared to produce stronger evidence for a local processing bias in Asperger syndrome than for auditory processing alone (Beversdorf et al., 1998; Jolliffe & Baron-Cohen 1999, 2000). This contradicts previous findings that multimodal coupling is impaired for people with Asperger syndrome (Iarocci & McDonald, 2006).

1.4.8 Gender considerations. Most studies recruitment reflected the prevalence of autism being four times greater in men (Center for Disease Control and Prevention, 2010). However, Katagiri et al. (2013) had a higher ratio of female participants and Bölte et al. (2007) only recruited males, raising the possibility that these were atypical samples. Plaisted et al. (1998) did not match gender between groups and subsequently, gender may have been a confounding variable with these results.

1.4.9 Sample sizes. Within this systematic review (see Section 1.4) it is noticeable the sample sizes for the reviewed studies appear to be modest. Additionally, with the exception of Bölte et al. (2007) power calculations are not reported when determining sample size for the respective studies. If the *a priori*

power calculations of Bölte et al. are taken as valid then all studies are sufficiently powered. However, the absence of reported power calculations in the majority of the reviewed studies impacts on the reliability of detectable changes being observed (Clark-Carter, 1997). Thus, potentially without sufficient power any changes a variable makes, either between groups or within group, will be missed and the Null Hypothesis accepted in error. Furthermore, only Spek et al. (2011) and Barnes and Baron-Cohen (2012) reported Effect Sizes (ES) that were moderate (d = 0.6) and large (d = 1.25), respectively (Cohen, 1988). A benefit of reporting ES is that it enables the degree of observed change to be deduced irrespective of sample size. Thus, caution should be used in drawing conclusions from the reviewed studies as many may be under powered to detected differences between people with and without Asperger syndrome and/or differences between people across the autistic spectrum.

1.4.10 Summary of Findings. Encouragingly, all but two (Beversdorf et al., 1998; Nakano et al., 2012) of the reviewed studies reported some degree of local processing bias for people with Asperger syndrome. A consistent feature of the studies reviewed was the employment of rigorous procedures, utilising reliable and validated diagnostic or screening tools to confirm the Asperger syndrome diagnosis in accordance with DSM-IV (APA, 1994) or ICD-10 (WHO, 1993). Additionally, the level of autistic traits was screened in the control groups to control for neurologically typical individuals either, having undiagnosed Asperger syndrome, or making sense of the world in a way too similar to people with the condition. It is noteworthy that only one clinical group included low functioning adults with autism (n = 5; Nakano et al., 2012), with high functioning autism or Asperger syndrome representing people with autistic spectrum

disorder. People with low functioning autistic spectrum disorder would have more pronounced cognitive impairments but may not have been able to engage in research (Scherf, Luna, Kimchi, Minshew, & Behrmann, 2008). One explanation for the absence within research of low functioning adults with autistic spectrum disorder could be that they would simply be unable to understand and complete the tasks required of them within the respective studies. Whilst Asperger syndrome shares diagnostic features of autism, people have unimpaired intellectual ability. The focus of research on high functioning autism and Asperger syndrome creates uniformity and easier comparisons between studies but inhibits direct comparisons with the few low functioning autistic spectrum disorder samples within research.

More specifically, the research reviewed using auditory stimuli produced some results inconsistent with the WCCT. Much more positive support for the theory came from visual processing tasks involving novel and multimodal stimuli, while facial recognition tasks unanimously supported the WCCT. The use of facial recognition and novel tasks demonstrates that people with Asperger syndrome could undertake global processing if explicitly instructed to do so but more slowly than people without Asperger syndrome (Behrmann et al., 2006). Consequently, people with Asperger syndrome should be afforded additional time to see if they can process global information. Even with the potential for global processing, a local processing bias for people with Asperger syndrome may prevent vital contextual information being processed that enables learning to be generalised to different contexts (Plaisted et al., 1998).

1.4.11 Conclusions from systematic literature review. When forming conclusions about the reviewed studies it is important to outline some limitations with the systematic review, and subsequently how these impact on the validity and generalisability of the conclusions. In reviewing the search strategy study selection criteria, it is possible that the narrow scope of the terms used, such as ‘‘weak central coherence’’, created a selection bias which may have threatened the validity of the conclusions. By using alternative or additional terms, such as ‘attention to detail’, which would have broadened the search, more studies may have been captured. Additionally, when reviewing conclusions drawn from the literature review it is important to acknowledge that a third of the fifteen studies reviewed used the same sample of participants. Looking at the participant characteristics in Table 1, it becomes apparent the five studies conducted by Jolliffe & Baron-Cohen (1997, 1999, 2000, 2001a & 2001b) form part of the same PhD, and in essence tested multiple hypotheses using the same sample. With such a high proportion of the reviewed studies accounted for by this one sample, the generalisability of the conclusions to the wider population of people with autistic spectrum conditions can be questioned. As a consequence, due to the limitations of studies not reporting power calculations and samples being under representative of Asperger syndrome populations, the resulting conclusions should be considered with caution.

Regardless of the methodological limitations outlined, support for a local processing bias for people with Asperger syndrome has come from facial recognition tasks, when multimodal processing and to a lesser extent, for visual processing of novel stimuli. The majority of the current literature has focused on face processing tasks, including emotion and gender identification (Teunisse &

De Gelder, 2003), or global deficits and local processing bias using specifically devised stimuli.

As noted within the diagnostic criteria, Asperger syndrome is one of five disorders within the classification of pervasive developmental disorders (PDDs). Accordingly, a review of the WCCT should also consider the viability of a single information processing theory accounting for the range of impairments within autism (Howlin, 2004). Furthermore, clarification is needed on whether the local processing bias in Asperger syndrome reflects an unconscious processing preference or represents a deficit in integrating information. Similarly, it remains unclear if the relationship between local and global processing is inversely proportionate or proportionate in nature. Finally, there remains a shortage of research exploring the WCCT and processing styles in adults with Asperger syndrome (Jolliffe & Baron-Cohen, 1997). Therefore, it was important for the literature review to explore the extent to which the WCCT was supported by observed enhanced local and reduced global processing styles in adults with Asperger syndrome.

On the whole, clinical groups have a local processing bias as opposed to focusing on contextual information. Research testing the WCCT looked beyond what is processed to explore how information is processed differently in adults with and without Asperger syndrome (Barnes & Baron-Cohen, 2012). Local processing bias in Asperger syndrome appeared to be perceptual (Happé, 1996). The second part of the WCCT, proposing impaired information integration capabilities for people with Asperger syndrome, remains unclear from the research reviewed. Happé (1996) described that global impairments occur at the

pre-attentive level and thus context would not be processed. Jolliffe and Baron-Cohen (20001a & 2001b) asked participants to integrate local features into a coherent whole; thus testing the second assumption of the WCCT. It was suggested global impairments appeared to involve conceptual processing requiring integration of information. The global impairments reported are interpreted cautiously because fragmented stimuli could draw attentional bias towards local features. Overall, it also remains unclear whether a local bias prevents access to pre-requisite contextual knowledge or whether the global features remain unprocessed.

When reviewing the WCCT (Happé & Frith, 2006) additional theoretical limitations are apparent that are not highlighted within the reviewed studies. The concepts of 'weak central coherence' and 'integration' of information arguably remain ill-defined, with the cognitive mechanism of local and global processing far from fully understood (Brock, Norbury, Einav, & Nation, 2008). It is suggested the proposed local processing inclination and difficulties integrating bits of information into meaningful representations depends on the individual characteristics of people with autism/Asperger syndrome, such as language capabilities (Brock, Norbury, Einav, & Nation, 2008). Arguably, such factors will have been omitted from exploration in the reviewed studies as little attention was given to within group characteristics of people with autism or Asperger syndrome. As a consequence, the WCCT has been over extended to explain the autistic condition without adequate details on the range variations in processing capabilities and tendencies, and explanations for such differences, for people across the spectrum.

More specifically, the WCCT does not appear to make reference to variations in individual local and global processing across visuospatial and linguistic tasks: with some people with Asperger syndrome performing well at both task while others displaying superior performance in one or the other task (Loth, Gómez, & Happé, 2008). It seems studies reviewing the WCCT have given little attention to systematically investigated individual constructs within groups of people with Asperger syndrome or autism per se (Vanegas & Davidson, 2015). Indeed, Vanegas and Davidson (2015) highlighted that visuospatial cognitive bias differed between children with high-functioning autism and Asperger syndrome: the latter presenting as similar to neurological typical peers. Thus, it becomes difficult to determine the theoretical relevance of the WCCT across the range of presentations within the autistic spectrum condition, which is particularly pertinent given the diagnostic continuum criteria proposed by DSM-5 (APA, 2013).

The WCCT originally proposed that local and global processing formed part of a continuum (Happé & Booth, 2008), with superior performance in one creating a deficit in the other. As evidence emerged of global processing in Asperger syndrome and autism per se (Rondan & Deruelle, 2007), the WCCT was revised. Subsequently, Happé and Frith (2006) proposed local processing bias as a dominant cognitive style in Asperger syndrome, which can be overridden if tasks explicitly require global processing. A dissociation between global and local processing in Asperger syndrome had been muted (Jolliffe & Baron-Cohen, 2001a), but more recently Porter and Coltheart (2006) and then Katagiri et al. (2013), argued that global and local processing involve independent mechanisms. If so, theoretically global processing can be

augmented in Asperger syndrome without detrimental effects to local processing. Although theory at present does not indicate if augmenting global processing could be sustained or trained for people with Asperger syndrome or autism.

To date, only one study has made use of a computerised training paradigm. The specific training paradigm was designed to train facial recognition skills in children with Asperger syndrome in a large scale randomised control trial (Tanaka et al., 2010). This research indicated a relatively short-term intervention programme can produce measureable improvements in the face recognition skills of children with Asperger syndrome, based on quick and accurate recognition. However, further exploration to establish if training paradigms can enhance global processing styles in people with Asperger syndrome is needed.

1.5 Factors associated with information processing

1.5.1 IQ. Intelligence is usually expressed as a score obtained relative to that of the general population, with an average score of one hundred and a standard deviation of fifteen. A test of intelligence measures both verbal and nonverbal abilities: known as verbal IQ and performance IQ. Performance IQ can be influenced by both processing speed and education level of the person. The abbreviated WASI-II (Wechsler, 1999) uses the matrix reasoning subtest and overcomes the influence of processing speed as the task is not time limited. Additionally, education level achieved by participants was collected within the demographic details screening to later assess the impact the variable has on the results.

1.5.2 Handedness. The handedness of participants is an important consideration due to the lateralisation of function within the brain and the impact this has on cognitive functioning. For a person the dominant hemisphere, in the majority of cases is the one that contains the speech centre of the brain (Tantam, 2012). For the vast majority of people, almost all right-handed people and half of left handed people, the left cerebral hemisphere is dominant. Typically then, about ninety seven percent of the population have a left hemisphere dominant brain. Our awareness of the functionality of the right cerebral hemisphere is still incomplete (Barr, 2003). It is known that the right hemisphere is used for visuospatial perception suggesting capacity for language production is reduced (Gazzaniga, 2000). Some right hemisphere capabilities, such as holistic face processing are affected in autism and Asperger syndrome (Kingstone, Friesen & Gazzaniga, 2000). Thus, it appears appropriate to monitor handedness between groups to minimise 'dominant hemisphere' variation between groups. Unfortunately, this thesis does not have access to brain imagery techniques and assumes half the left handed people may be right hemisphere dominant.

1.5.3 Gender considerations. Evidence for sexual dimorphism in human brains remains strong, and may be one cause of gender difference in behaviour after birth (Hines, 2010). As this study is recruiting people with Asperger syndrome it will be mindful of matching groups on gender but aware that ratios currently published may misrepresent the true gender ratios in such samples.

1.5.4 Augmenting processing styles. When processing information a precedence refers to the level of processing (local or global) to which attention is first directed. People typically focus on global features first before moving onto

the finer (local) details. Interference is represented by a delay in responding to one level of a stimulus when the other level is different. Navon (1981) proposed that if both global processing advantage and global to local interference occurs then a global precedence effect happens, as proposed for typically developing adults. Conversely, Rinehart et al. (2001) found people with Asperger syndrome had difficulty switching from local to global information and a local bias showing local precedence. Perceptual flexibility can also be tested and refers to the ease or difficulty of switching attention between global and local levels of processing.

In augmenting processing styles it is hoped that interference between the local and global levels of processing will be reduced. Additionally, enhancing global processing would increase people's ability to increase the spread of visual attention to include peripheral target information (Mann & Walker, 2003). Any augmented processing would be observable in faster reaction time when identifying global or local elements of information.

1.5.5 Clinical Relevance. To make sense of information **p**eople with Asperger syndrome are said to focus on the finer details, rather than understand the bigger picture (Happé, 1999). In contrast, typically developing individuals were proposed to have 'central coherence', which entails the ability to integrate information by using contextual information (Hill & Frith, 2003). To elucidate how people with Asperger syndrome make sense of information the Weak Central Coherence Theory (WCCT; Happé & Frith, 2006) proposed that those with Asperger syndrome have a detail-focused local processing style, arising from difficulties integrating pieces of information into a coherent or global whole

(Frith & Happé, 1994). Although, whether an inversely proportionate relationship exists between local and global processing is unclear.

Much of the literature supported the existence of a local processing bias for people with Asperger syndrome. What has remained unclear is the validity of the proposed impaired ability to integrate pieces of information into a coherent or global whole. The WCCT account of information processing was supported by a range of research, such as facial recognition tasks (Behrmann et al., 2006; Rondan and Deruelle 2007), when engaging in multi-modal processing (Nakano, Kato & Kitazawa 2012) and in part for the visual processing of novel stimuli (Jolliffe & Baron-Cohen, 1997; Bölte, Holtmann, Poustka, Scheurich, & Schmidt, 2007). While much research had tested processing styles in children with Asperger syndrome, there was a scarcity of research using adults (Jolliffe & Baron-Cohen, 1997).

Beyond clarifying the local processing bias in Asperger syndrome, a number of directions for future research seemed viable. A review of the literature found that attempting to modify processing styles in people with Asperger syndrome has as yet remained unexplored. Research investigating how best to support the processing styles of people with Asperger syndrome has contributed to the development of some coaching paradigms (Wentz, Nyden & Krevers, 2012) and face-training programs (Faja, Aylward, Bernier & Dawson, 2008). Crucially, the flexibility of processing styles for people with Asperger syndrome remains untested. If processing styles can be modified, interventions could be adapted to individual needs and become accessible in people's homes (Tanaka et al., 2010). Research could subsequently track how changes in processing style

translated to functioning in everyday life for individuals with Asperger syndrome.

1.6 Aims. The purpose of this study is to determine whether a training paradigm can enhance global processing style in individuals with Asperger syndrome. To achieve this goal a computerised training paradigm, comprising of Navon (1977) Figures, will be used to enhance global processing style in people with Asperger syndrome and typically developing controls. Trials at the global level will be repeatedly presented in a global training condition. This will be compared against an attentional control paradigm consisting of an equal ratio of global and local trials. It is predicted that Asperger syndrome individuals will display a higher ratio of local processing bias than typically developing controls. It is further hypothesised that the global training paradigm will enhance global processing style in adults with Asperger syndrome. To our knowledge, this would be the first study to investigate the effect of global training paradigms on processing styles in individuals with Asperger syndrome.

As a consequence, using an experimental design, the study aimed to investigate whether or not a training paradigm can enhance global processing styles in adults with and without Asperger syndrome. The two groups of participants were recruited from the community and randomly assigned to receive training which enhances global processing style or an attentional control condition, which was thought less likely to enhance a global processing style. The WCCT (Frith & Happé, 1994) has traditionally been used to explain non-social aspects of Asperger syndrome (Hill & Frith, 2003). Thus, it is unlikely the results from this thesis will extend to clarifying links between cognitive

processing styles and everyday atypical behaviour by individuals with Asperger syndrome (Geurts, Corbett & Solomon, 2009).

A viable computerised training programme to enhance global processing styles for people with Asperger syndrome has many proposed benefits. From a practical standpoint, a computer-based training paradigm for global processing enhancement could be cost free, can become accessible at individuals homes or within clinical environments and used on multiple media formats (Tanaka et al., 2010). A successful training paradigm could be customised to the individual's needs and used at times most convenient around life demands. Subsequently, research could be developed to see how much improvements achieved from training paradigms translate to the social environment for individuals with Asperger syndrome (Tanaka et al., 2010). A shift towards a global processing style may have beneficial effects upon Asperger syndrome symptomatology by reducing cognitive rigidity as processing becomes less focused on the finer or local details.

1.7 Research Questions.

Primary:

1) Is there a difference in local/global processing bias between typically developing adults and adults with Asperger syndrome, when naming local or global letters that have a differing letter at both the local and global level.

2) Can computerised training paradigms enhance global processing style in adults with Asperger syndrome? When compared to adults with Asperger syndrome receiving attentional control condition, and typically developing adults receiving either global training or attentional control condition.

1.8 Hypotheses:

Given the previous research findings outlined, it was hypothesised:

a.) Adults with Asperger syndrome will demonstrate a local processing bias, by performing significantly better in local processing trials, when compared with a typically developing control group.

b.) Adults with Asperger syndrome will demonstrate global processing deficits, with typically developing controls predicted to have significantly superior performance in global processing trials.

c.) Global processing will significantly increase for Asperger syndrome and typically developing groups in the global training condition, when compared to groups in the attentional control condition.

An abridged version of the global training paradigm was used in a non-clinical sample by Hoppitt (2012) with an Effect Size of $f = 0.23$. As this is the first study attempting to modify global processing in a clinical sample of individuals with Asperger syndrome, the magnitude of the differences when compared to a typically developing control group is unknown.

Chapter Two

Methodology

2.1 Introduction

This chapter begins by outlining the design used to answer the research questions described in Chapter One. It then continues by describing the participant characteristics included in the study, their demographics, and the power calculations used to determine the sample size. Further details are also included on the participant inclusion and exclusion criteria. Ethical considerations are discussed prior to a description of the assessment measures chosen to provide the data to answer the research questions. A description of the procedure is given, followed by an outline of the statistical analyses used to analyse the data in relation to the research questions. The chapter will provide a detailed overview of the participant characteristics. Following this, the chapter will describe how the study's data were screened and how parametric assumptions were tested and fulfilled after further outliers were removed.

2.2 Design

This study employed a 2 (Group: Asperger syndrome or typically developing) x 2 (Training: attentional control or global) x (2 (Time: 1 or 2) mixed experimental design *x S*) yielding four groups. Two groups of participants, adults with Asperger syndrome and typically developing adults, were randomly assigned to one of two conditions, global training or attentional control.

2.3 Participants

Forty adults (24 men and 16 women, *M* age = 32.33, *SD* = 9.84) were recruited for the study. A group of 20 typically developing adults (12 men and 8 women, *M* age = 33.8, *SD* = 8.8) were matched by gender to a group of 20 adults with a diagnosis of Asperger syndrome (12 men and 8 women, *M* age = 30.85, *SD* = 10.77). Participants were randomly allocated to either a training or attentional control condition, stratified by gender: adopting a pragmatic approach of equal but an undetermined gender ratio after the intended ratio of four men to every female became unachievable. A group of 10 participants with Asperger syndrome completed the global training (6 men and 4 women, *M* age = 30.8, *SD* = 12.21), while 10 Asperger syndrome adults were assigned the attentional control condition (6 men and 4 women, *M* age = 30.9, *SD* = 9.85). Similarly, 10 typically developing adults matched on gender, were randomly assigned to receive global training (6 men and 4 women, *M* age = 33.4, *SD* = 7.78), while 10 randomly assigned typically developing adults received the attentional control condition (6 men and 4 women, *M* age = 34.2, *SD* = 10.13).

2.3.1 ***Recruitment.*** To recruit participants, the study was presented to Asperger East Anglia services. The awareness presentations started with the Asperger East Anglia Chief Executive Officer and then moved to briefing the staff team about the nature of the intended study. The plan was to enable Asperger East Anglia service Support Workers to promote the study to individual clients with Asperger syndrome. To further advertise the study, posters were placed at Asperger East Anglia offices, UEA campus and NHS premises. To progress the recruitment of people with Asperger syndrome, further adverts were

placed in Asperger East Anglia service online newsletters. Adverts provided details of the study and contact information if participants were interested in obtaining more details about the research (see Appendix G). This study primarily recruited individuals with Asperger syndrome from Asperger East Anglia support groups and newsletter audience.

Information sheets (Appendix C & D) were provided to Asperger East Anglia, and the agency passed these onto potential participants. Unfortunately, individual contact by Support Workers with people with Asperger syndrome yielded little interest in the study. The option was taken to repeatedly attend evening support groups organised by Asperger East Anglia service, for people with Asperger syndrome living in East Anglia. Different groups were available based on the social functionality of the people with Asperger syndrome. The researcher repeatedly attended the support groups and completed presentations about the study. Consequently, the researcher became more familiar to the people attending the groups and people with Asperger syndrome were better informed about the study. Information packs were made available at the awareness sessions for people to take if they were interested in finding out more about the study. The information packs contained the Participant Information Sheet for people with Asperger syndrome (Appendix C), consent to share details form (Appendix E), a consent form (Appendix F) and a stamped addressed envelope to send to the researcher if they wished to be contacted about the study. At the respective support groups, approximately 40 information packs were taken by people with Asperger syndrome. It is estimated that 10 returns came from the groups and provided a response rate of approximately twenty five percent. Anecdotally, many people with Asperger syndrome attending the groups had

taken part in successive UEA research trials and wanted a break from taking part in research.

As recruitment progressed it became apparent that the required quota of twenty adults with Asperger syndrome was unachievable within the original time parameters. To further publicise the study, online resources were utilised. The online resources consisted of a webpage link on the Asperger East Anglia homepage and an advert in the online newsletter '*Street life'* to publicise the study. If people expressed an interest in the study, they would be sent the same information packs as those made available at the awareness presentations. Typically, people with Asperger syndrome preferred to be sent information and to correspond via email rather than engage in telephone conversations. The use of '*Street life*' had a positive impact on recruitment for people with Asperger syndrome.

Overall, four people with Asperger syndrome enquiring about the study met the exclusion criterion and were ineligible to take part. Two people were yet to receive their diagnosis of Asperger syndrome and the other two people were under the age of 18 years. Another potential participant with Asperger syndrome lived too far away to realistically be included within the study.

Typically developing control participants were recruited from the local community within East Anglia, with groups to be matched on baseline demographics of age, gender, education level, IQ and handedness. Having more closely matched groups would ensure that the observed differences could be reliably attributed to the independent variable, in this case presence or absence of Asperger syndrome and training. Typically, people without Asperger syndrome

were equally happy being sent study information either electronically or by post and contacted via email or telephone. Approximately 33 information packs were sent to people without Asperger syndrome interested in taking part in the study. It is estimated that 22 returns came back and provided a response rate of sixty seven percent for the control group.

2.3.2 Sample size and power calculation. The closest previous research to base the a priori power analysis[1] was that of Katagiri et al., (2013). This study compared Asperger syndrome and typically developing controls in a repeated levels trials switching attention between local to global processing of Navon (1977) type hierarchical figures (n = 11 for Asperger syndrome, and n = 11 for typically developing controls). No effect size or Power calculations were reported by this study. A paper by Hoppitt (2012), used a global and local training paradigm with a student population (n = 40), to explore if changes in global processing bias produces a change in emotional responses. Hoppitt (2012) reported p = 0.06 and an Effect Size (ES) was calculated of d = 0.36 for the local training condition and d = 0.59 for the global training condition. The current study adopted the Hoppitt (2012) global processing training paradigm. Using the average ES of d = 0.48, as the training paradigm had not previously been trialled for people with Asperger syndrome, this was converted to f = 0.23. Looking at change across the repeated measures factor (time), with statistical power at 0.8 and alpha at 0.05, it was calculated that 10 participants needed to be recruited in

[1] [1] Power analyses calculated using GPower version 3 (Appendix I).

each group for this study (total sample; n = 40, Appendix I). This provided sufficient power for the primary research questions (completing an ANCOVA).

2.3.3 *Criteria*. Inclusion and exclusion criterion were specified to ensure the Asperger syndrome group represented an appropriate sample of the Asperger syndrome population and to ensure the typically developing group represented a suitable comparison group.

2.3.3.1 Inclusion criteria. All participants were adults (18-65 years; males & females) and were required to have estimated WASI-II IQ score above 80 (the WASI-II, see section 2.4.1). No participants were excluded for obtaining an IQ score below 80. To be included in the Asperger syndrome group, participants were asked to confirm a formal diagnosis of Asperger syndrome or a Pervasive Developmental Disorder – Not Specified, in accordance with ICD-10 (WHO, 1993). To safeguard against misdiagnosis the autism screening tool of the Autism Spectrum Quotient 10-item (AQ-10, see section 2.4.2) was used to ensure the clinical group presented with a high level of autistic-like traits. Allison, Auyeung and Baron-Cohen (2012) advise that a score of 6 or above is required for level of autistic-like traits required for further diagnostic exploration and thus consistent with Asperger syndrome. Of the 20 participants in the two Asperger syndrome groups, 17 scored 6 or above and 3 scored below 6, with scores ranging from 4 to 10 on the AQ-10 (Appendix B). The modal response was 10. It was decided to include participants diagnosed with Asperger syndrome with low levels of autistic-like traits because to exclude them would have reduced the sample size. Additionally, there was no exclusion criterion to this end. Discussing these scores with respective participants all three indicated they

would have scored higher on items relating to communication and social impairments scores at the time of their respective diagnosis some years ago. It appeared that these particularly high functioning individuals with Asperger syndrome had developed adaptive strategies to compensate for potential deficiencies within their social skills.

For the typically developing group, participants would be included if they did not have a formal diagnosis of Asperger syndrome or of autism or atypical autism, in accordance with ICD-10 (WHO, 1993). Additionally, typically developing participants were required to score below 6 on the AQ, be of a similar age, gender, IQ, handedness and education level to the Asperger syndrome groups. This allowed the groups to be matched as best as possible, but the study did not attempt to match participants at an individual level. For the participants included within the typically developing group the AQ-10 scores ranged from 0 to 5, with 18 of the twenty participants scoring between 0 and 3. The modal AQ-10 score was 0 for the typically developing group.

2.3.3.2 ***Exclusion criteria.*** If participants were ineligible for the study, feedback was provided outlining this. Reasons could have included participants having difficulty understanding the task due to lower intelligence quotient or not having proficient English language. A good grasp of the English language was required to be able to understand and follow the written instructions presented within the computerised training paradigm. Participants were also ineligible by not having capacity to give or withhold consent to take part in this study

Additionally, typically developing controls would have been excluded if they have ever had a formal diagnosis of autism or atypical autism, in accordance

with ICD-10 (WHO, 1993) or having high autistic-like traits. A score of 6 or above as tested for by the AQ-10 (Allison, Auyeung and Baron-Cohen, 2012; Booth et al., 2013) was deemed as representing high autistic-like traits. One typically developing participant met the exclusion criterion by scoring 7 on the AQ-10. The answers were discussed with the participant and appeared to be caused by the person being overly critical of their social and emotional functioning. Nonetheless, the participant's screening data was removed from the thesis and destroyed. Additionally, the person was advised to seek further support from their General Practitioners.

2.3.3.3 *Screening*. Once initial consent to contact had been attained, the researcher contacted the individual by phone or email to meet and go through the inclusion and exclusion criteria to deduce eligibility to partake. Once initial eligibility criteria were met and individuals were willing to participate, an invitation was extended to take part in the randomised experiment. A convenient contact time for the individuals was arranged. Participants were asked to sign written consent forms, which outlined that participation in the study was only permitted if all inclusion criteria were met (see Appendix F).

After gaining consent, the screening process commenced, initially collecting demographic and medical details of participants (Appendix A). Prior to the commencement of any screening assessments, participants were given a brief verbal description of the task, along with clear instructions that they were free to discontinue the task at any time, without needing to provide a reason. Participants were required to be in good physical health, proficient in the English language and without a history of neuropsychiatric disorder or traumatic brain

injury. This was followed by establishing IQ using the abbreviated WASI, and autistic-like traits using the AQ-10, for all participants. In practice participants preferred to meet to cover the consent process, eligibility criterion, screening process and complete the computer study, all within the same visit.

The screening process of completing the AQ-10 was exclusively completed face to face with people with Asperger syndrome. For the typically developing participants it was explained that they may become ineligible to take part after the screening process. Consequently, approximately half of typically developing participants completed the AQ-10 via the telephone, and the other half face to face. After screening, participants meeting the exclusion criterion became ineligible to partake in the study.

The final part of the screening process comprised of the Wechsler abbreviated scale of intelligence (WASI-II: Wechsler, 1999). The abbreviated WASI-II was completed at either a standardised test location or at participants' homes. The completion of the abbreviated WASI-II took considerably longer than anticipated for some of the participants with a diagnosis of Asperger syndrome. The additional time taken was most noticeable on the Matrix Reasoning subtest, which provides a measure of perceptual reasoning. It appeared people with Asperger syndrome were relentless in deducing the right answer in the logical pattern subtest. The overall consent and screening process of the demographic questionnaire, AQ-10 and abbreviated WASI-II took approximately 45 to 60 minutes to complete.

2.4 Assessment measures

The measures used to establish an estimated IQ, autistic-like traits and local/global processing score will be described in turn. Psychometric properties

for respective measures are reported, with further test details available in Appendix B and H.

2.4.1 Wechsler abbreviated scale of intelligence (WASI-II; Wechsler, 1999).

An estimated IQ score was obtained for each participant using the abbreviated WASI-II (Wechsler, 1999). The abbreviated version of the WASI-II comprises of the Vocabulary and Matrix Reasoning subtests. In accordance with the test manual, estimates of Verbal IQ (VIQ) and Performance IQ (PIQ) were derived by doubling the *T* scores. An estimated Full Scale (FSIQ) intelligence score comprised of the average of the VIQ and PIQ. The WASI-II (Wechsler, 1999), was used as opposed to the full test of intelligence offered by the WAIS-III (Wechsler Adult Intelligence Scale – Third Edition, 1999) or more recent WAIS-IV version for brevity, to reduce the time demands placed on participants. The same reasoning was applied when using the abbreviated version of the WASI-II, rather that the full four subtest WASI-II. The abbreviated version was developed as a short and reliable measure of intelligence and is now utilised in clinical and research settings. If cases had arisen in which participants had an IQ test administered clinically within the last year, the WASI-II would not have been used, and scores from the previous administration would be utilised for the purposes of the present study. A cut-off IQ (>80) was used, as this has typically been used when assessing individuals with Asperger Syndrome for use within research (Hayward et al., 2012).

The overall reliability coefficients for the adult sample (16-89 years) are .96, .96, and .98 for the VIQ, PIQ, and FSIQ respectively. The average stability coefficients are .87, .92, and .92 for PIQ, VIQ, and FSIQ respectively, which indicates adequate reliability across time. The validity of the WASI-II is upheld

by the correlation for the respective IQ scales it has with the longer WAIS-IV: .88, .84, and .92 for VIQ, PIQ and FSIQ.

2.4.2 Autism spectrum quotient-10 (AQ-10; Allison, Auyeung, & Baron-Cohen, 2012).

Self-report measures examine the cognitive and behavioural features of self-perceived local information processing and systemising tendencies (Spek et al., 2011). Research asking individuals with Asperger syndrome to self-report, appears to be positive for high-functioning individuals (Hobson, Chidambi, Lee, Meyer, 2006; Spek et al., 2009). This study did not recruit low functioning adults with Asperger syndrome, and the clinical groups were high-functioning in terms of abbreviated IQ scores attained.

The original Autism spectrum quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin & Clubley, 2001) is a 50-item questionnaire, based on a four point Likert scale (1 = definitely agree, to 4 = definitely disagree). The AQ has five subscales: social interaction, communication, attention to detail, attention switching and imagination. A score of one point is given for each 'autistic-like' trait described. A total score is obtained with a range from zero to fifty, thus having a large variance to discriminate between those people with and without autistic-like traits. Scores of 30 and above have been deemed to be representative of a level of severity typical within autism (Baron-Cohen et al., 2001). In addition to displaying behavioural characteristics typical within autism, individuals scoring high on the AQ have found to present with similar cognitive profiles of individuals diagnosed with autism (Almeida et al., 2010a).

The AQ was validated using four groups of adult participants: Asperger syndrome (M = 35.8, SD = 6.5), randomly selected controls (M = 16.4, SD = 6.3),

Cambridge University students (M = 18.6, SD = 6.6), and UK Mathematics Olympiads (M = 24.5, SD = 5.7). It is observable that the Mathematic Olympiad group scored significantly higher than the other two comparison groups. The retest reliability of the AQ was determined using the Cambridge University students and the scores did not differ from the first test ($t(16) = 0.3$, $p = .002$), and the two tests produced a strong correlation ($r = .7$, $p = .002$). By using Cronbach's alpha coefficients the internal consistency between respective domains ranged from moderate to high (social interaction = .77; communication = .65; attention to detail = .63; attention switching = .67; imagination = .65). Good internal consistency and test-retest reliability of the AQ is also reported by research independent of the original authors (Hoekstra, Bartels, Cath, & Boomsma, 2008). The AQ is commonly used within research as a reliable measure to establish self-reported autistic-like traits (Russell-Smith, Mayberry, Bayliss, & Adelln, 2012).

An abridged version of the AQ, a 10-item AQ has been developed as a brief screening tool for autistic spectrum disorders (Allison et al., 2012). The AQ-10 uses two items with the most discriminative power from each of the five subscales (social interaction, communication, attention to detail, attention switching and imagination). The AQ-10 has reported psychometric properties of 0.88 for sensitivity, 0.91 for specificity and a positive predictive value of 0.85 (Allison et al., 2012). The AQ-10 (Appendix B) was used to assess the level of autistic-like traits in all groups. The AQ-10 was selected over the AQ for brevity in order to reduce demands and time commitments of participants during the screening processing. The AQ-10 is not considered as labour intensive or time consuming as formal diagnostic tools, such as The Autism Diagnostic

Observation Schedule (ADOS) (Lord et al., 1989) and the Autism Diagnostic Interview-Revised (ADI-Revised) (Lord, Rutter, & Le Couteur, 1994). It was important to minimise screening demands, whilst remaining reliable and valid, because participants could be deemed ineligible after giving up time for the screening process. The aim was to reaffirm the existing diagnosis of Asperger syndrome for the clinical group, while for the typically developing controls it ensured that autistic-like traits were not a confounding variable within the results.

2.4.3 Training paradigm with Navon hierarchical letters (HL; Navon, 1977). A computerised assessment task and training paradigm was employed in order to provide information regarding the aforementioned hypotheses. The stimuli proposed within the training paradigm were hierarchical letters (HL). HLs can be presented in one of two types: congruent letters or incongruent letters. Congruent letters, in which big letter outline, known as the global letter, and little letter, known as local letters, share identity (e.g., a large L made up of smaller Ls or a large H made up of smaller Hs). Alternatively, incongruent letters, in which the letters at the two levels, global and local letters, are different (e.g., a large L made up of smaller Ts or a large F made up of smaller Hs; see Fig: 2). The global letter was 3.2 centimetres in height and 2.3 centimetres in width, and the local letters 0.44 centimetres in height and 0.53 centimetres in width. The background display for the letters was black with all letters white in colour. Navon (1977) HLs appear to be effective for measuring both local and global processing style when used in divided attention tasks requiring either local or global elements to be processed (Happé and Frith, 2006).

The correct construction and proper use of Navon (1977) HLs has proved to be essential in ensuring construct validly remains intact when testing local and

global processing styles (Wang et al., 2012). By adhering to standardised approaches to devise and display stimuli and having consistent exposure time and visual angle for stimuli (HLs), the results should be consistent and comparable to other studies using HLs (Kimchi, 1992). This was achieved by using a training paradigm from Hoppitt (2012), which when used in a non-clinical sample produced an Effect Size of $f = 0.23$.

In the version of the task performed, in separate blocks of trials, participants identified the letter, via key press on a serial response box, at either the global or local level. Additionally, focusing on both reaction time taken and accuracy in identifying HLs (Navon, 1977), enables greater accuracy in detecting differences in participants processing styles (Behrmann et al., 2006). All else being equal, it was hypothesised that the typically developing controls identify the global letters faster and more accurately than the local letters, with the reverse results expected for adults with Asperger syndrome.

2.5 Procedure

2.5.1 Assessment procedure. The method of the study was appropriate to gain the data needed to answer the research questions posed. In this stance, the training paradigm was sufficient to obtain data pertaining to information processing styles, whilst the screening questionnaire (AQ-10; Allison et al., 2012) sufficiently measured level of autistic-like traits in the population. A formal IQ test, the abbreviated WASI-II, was needed to obtain information on intelligence, while a short demographic questionnaire was used to gather additional information used to assess if groups were matched on certain variables.

The experiment, where possible, took place at a designated room at Asperger East Anglia premises. This helped to standardise test conditions and prevent testing interruptions that would have otherwise made participants data un-useable. Some participants expressed a desire to be involved in the study but were either unwilling or unable to travel to the designated room at Asperger East Anglia premises. In these instances the experiment was conducted at participant's homes or a mutually convenient setting. Arranging to meet people with Asperger syndrome took additional time as people had difficulty making changes to a very structured and rigid routine (Baron-Cohen, 2001). It was clearly explained if interruptions occurred during the computerised assessment or training trial then participation would cease. Fortunately, conducting the experiment in participant's homes was interruption free.

It was noticeable that people with Asperger syndrome preferred to be seen at the two standardised Asperger East Anglia premises. For some people with Asperger syndrome the notion of allowing a stranger to visit their home appeared an uncomfortable prospect, preferring the security of familiar but more neutral territory. In total 18 of the 20 AS group were seen at a standardised test site, while the remaining 2 participants were seen at their respective homes. The test conditions differed slightly for the control group, with 16 people undertaking the study in a standardised room and 4 people seen at their homes. Far more of the control group would have preferred to be seen at home but respected the need to standardised test conditions. Regardless of the location, the assessments and training paradigms were always conducted in a quiet room to reduce distractions and to standardise test conditions.

Each experimental trial was conducted on the same Toshiba Satellite C660-1JH laptop (17 in. monitor) and executed with E-Prime 2.0 Professional version software (Psychology Software Tools, Inc.). The viewing distance for each participant was approximately 50 cm. Stimuli were displayed in the centre of the monitor, and drawn in white on a black background (see Appendix H). All responses were recorded with two keys marked to identify stimulus response mapping on a serial response box. An Empirisoft DirectIN high speed nine button serial response box was used, with the first two buttons from left to right programmed to represent an 'L' and 'H' response. Participants were instructed to place an index finger from each hand over a separate response button. A letter "H" and "L" decal, measuring 3 centimetres, were placed above and below each response button in order for participants to have a clear and accessible response reference. Reaction time and accuracy was recorded in all tasks: pre-test, training and post-test.

To test global/local processing style, participants were presented with each figure on a computer screen and then asked to respond as quickly as possible as to whether it contains one of two target letters (e.g., "H" or "L") by pressing the appropriate key. Sometimes the target letters were randomly represented at the global level (large letters, Figure 2) and sometimes at the local level (small letters, Figure 3). The pre and post-test of global/local processing style consisted of 32 trials presented in succession, with an equal number of global and local trials randomly presented. This was preceded by 8 practice trials, which provided feedback on whether participants had correctly identified the target letter. The practice trials also enabled the researcher to determine if a participant was orientated to the task. If oriented to the task participants commenced with

the pre-test. If during the practice trials incorrect responses were evident then the researcher reiterated the question ‘‘Do you see an ‘‘H’’ or an ‘‘L’’?’’.

If participants were faster to accurately respond when the target letter is presented at the global level then you could assume that they are displaying a global cognitive style. Alternatively, if faster when the target letter was presented at the local level then you would assume that they are displaying a more local cognitive style. This task has been used successfully in this way to assess global/local processing by Forster & Higgins (2005). A local/global mean score was attained at pre and post-test for each participant, taking approximately 2 minutes each. The score uses both reaction time and accuracy, when identifying letters within trials. To prevent overall fatigue the participants undertook an enforced rest for 1 minute after the pre-test and training elements of the computerised test. The two separate minute rest periods were timed by the researcher to ensure the procedure was standardised for all participants. A failsafe operation was also built into the E-Prime programme to ensure the researcher used selected laptop keyboard keys to start the training/attention control and post-test components. The failsafe prevented participants accidentally or intentionally starting computer programme via the response box. Inevitably a few participants tried to start the next sequence of the computer programme prior to having the standardised break, but the failsafe worked. All participants remained seated at the computer for both designated breaks.

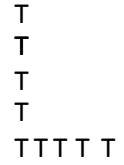

Figure 2. Global trial

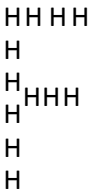

Figure 3. Local trial

Participants were randomly assigned to either global training or attentional control. Figure 1, is an example of a training trial for the global condition, where the participant was encouraged to focus on the global aspects of the figure in order to do well. In the global training condition, the target letter always appeared at the global level. The global training condition was presented with 128 of these trials successively in order to train changes in cognitive style. This lasted approximately 5-8 minutes, depending on the speed of participant’s responses. The attentional control paradigm had an equal number of local and global figures within the 128 trials.

2.5.2 Randomisation. The participants in this randomised experiment were divided into four groups: a) those who met ICD-10 requirements for Asperger syndrome, global training condition, b) those who met ICD-10 requirements for Asperger syndrome, attentional control condition, c) typically developing control, global training condition, d) typically developing controls, attentional control condition. Initially randomisation occurred by stratified sampling, ensuring the ratio of men and women between groups represented the prevalence of Asperger syndrome being four times greater for men (Center for Disease Control and Prevention, 2010).

The stratified sampling randomised the female participants for each group into a block of four, with an equal chance of being allocated to the training or attentional control condition. The male participants were randomised to either the training or attentional control condition. Subsequently, it became apparent that adhering to the proposed stratified sampling criteria of four men to every female would prolong recruitment beyond the timeframe parameters of the thesis. In part, this was due to the slow uptake in recruitment but generally greater interest in the study came from females. Meaning data had been collected relatively quickly for the proposed four females with Asperger syndrome and the four typically developing females. Additionally, more female participants for both groups were recruited and ready to participate. It was decided to adjust the stratified sampling criteria from the proposed prescribed gender ratios. Whilst stratified sampling remained, the recruitment strategy shifted to achieving the four groups of ten participants with equal but undetermined gender ratios. Once the Asperger syndrome groups had been recruited the final typically developing participants were recruited to ensure all four groups were matched on gender ratio. Randomisation to either the global training condition or attentional control condition was maintained for both groups.

2.6 Ethical considerations.

The need to consider ethical treatment of participants will be discussed here. Areas such as issues of confidentiality, recruitment, consent, withdrawal, receiving training, complaints procedures and other clinical issues, will all be addressed. The Asperger East Anglia organisation is jointly funded by Asperger

Service Norfolk and the NHS. Therefore, NHS ethical approval was needed prior to commencement of the study. Ethical approval was obtained from the Hatfield Research Ethics Committee. See Appendix L and M for confirmation of approval letters.

2.6.1 Confidentiality. It was considered ethical to protect the anonymity of participants. All study data was kept confidential, in accordance with the Data Protection Act 1984, with identifying information removed during the assessment process. To achieve this, on consenting to the study, each participant was randomly assigned a unique identification number for their data. The randomly assigned unique identifying number was not known by the researcher but enabled participants to identify their data should they wish to withdraw from the study and have their data destroyed. All participants were provided with the opportunity to take a written note of their unique identification number, as well as ensuring participants had a means of contacting the research via information provided on Participant Information Sheets (Appendix C & D).

Participants were made aware that information collected was confidential, but not anonymous due to the researcher having face to face contact with every participant. All questionnaires and assessments were kept in a locked cabinet on NHS property, and files and tasks on computers were password protected. Consent to share details forms and consent form, with identifiable participant information on, was stored separately to the respective screening forms distinguishable by a unique identifiable number. No confidential information on a client, that could identify them, was kept on a computer system. Limitations to confidentiality was outlined, emphasising that if current risk of harm to self or

others was disclosed, confidentiality would have been broken. During the study the researcher did not consider any information to require limits to confidentiality to be broken.

2.6.2 Informed consent. Individuals interested in finding out more about the study could contact the researcher (via email or telephone) to request receipt of an information sheet about the study. Information sheets (Appendix C & D) were provided to Asperger East Anglia, and the agency passed these onto potential participants. All participants were provided with written information about the purpose of the randomised experiment and given the opportunity to ask questions. A study outline was provided in the 'What is the purpose of the project?' section of the Participant Information Sheet. After a minimum of 24 hours of receiving the information sheet, potential participants received a follow up telephone call or email from the researcher to discuss the study further. Although, for potential participants taking information packs at support groups the time taken to return the consent to share details form would typically amount to several weeks.

All participants completed and returned the consent to share details form (Appendix E), prior to the researcher covering the consent process (Appendix F). Once initial consent to contact had been attained, the researcher contacted the individual by telephone or email and go through the inclusion and exclusion criteria to deduce eligibility to partake. If participants had completed the consent form prior to meeting with the researcher, the process was reviewed to ensure participants were able to provide informed consent. The purpose of the study

was reiterated prior to written consent being obtained, which was prior to screening or any aspect of the randomised experiment.

Determining capacity to consent was the responsibility of the person seeking consent; in this instance the researcher. Only participants who were able to give informed consent were included in the study. Should the researcher have decided that someone may not have capacity to provide or withhold consent then they would be ineligible from taking part in the study. Participants were asked to sign written consent forms, which outlines that participation in the training is only permitted if inclusion criteria are met (see Appendix F). Written consent was required from all participants.

At the time of providing consent participants were entered into a prize draw with a chance to win a £30 amazon voucher. Participants were assigned a prize draw number, which was separate and distinct to their unique data identification number. All prize draw numbers were transferred to tickets and entered into the prize draw. A ticket was picked at random by a member of the UEA staff team who was independent of the study.

2.6.3 Withdrawal. During the consent process, and clearly outlined on the consent form, it was emphasized to the participants that they had the ability to withdraw at any time without giving a reason. One participant did withdraw from the study after missing the intended appointment to undertake the screening process. The reason for withdrawal was a relapse in their mental health, for which support was being accessed via adult community mental health services. The participant had no further involvement with the study.

It was explicitly outlined that if the researcher detected participants were distressed during the study, then the study would stop immediately and they would be withdrawn from the study. Should participants have become distressed in the study, they would have been made aware that they were able to contact either research supervisors, both of whom had agreed to provide support in the above instance. In this situation, the researcher would inform the primary research supervisor about the situation; however no personal details would be shared. Fortunately, no participants became distressed during any part of the study.

If participants wished to query any aspect of the study they were able to contact the researcher in the first instance, and were also provided with names and contact details of respective supervisors via the participant information sheet. If participants felt unhappy about the way they have been treated during the study or wished to make a complaint, it was again advised to initially speak to the researcher who would do their best to resolve any problems. If people remained unsatisfied or wanted to complain formally, contact details of the Patient Advice and Liaison Service (PALS) was provided for further advice and information. Alternatively, complaints could be made directly to the Course Director of the Doctoral Programme in Clinical Psychology at the UEA. Participants needed an option to complain or seek advice from someone independent about taking part in research. To this effect the contact details for INVOLVE were included on the participant information sheets (Appendix C & D).

2.6.4 Debriefing. All participants were debriefed as to the nature of the study once participation was complete. Individual feedback was not available because the time taken to provide performance feedback was beyond the confines of the study. Additionally, participants had agreed to take part in the study and had not consented to receiving clinical feedback about their individual processing style. An option was provided on the consent form for participants to indicate whether they would like to receive a written summary of the research findings, again individual feedback was not available. All but one of the 40 participants requested a written summary of the findings on completion of the research.

2.6.5 Other Clinical Issues. Given that this study involved contact with a clinical group, Asperger syndrome, the researcher provided evidence of enhanced Disclosure and Barring vetting. Contact during the screening process happened on a number of occasions at participant's home, and on these occasions the UEA lone working policy was adhered to. The lone worker policy helped ensure researcher safety, with home visiting during normal working hours and a buddy system in place enabling the researcher's whereabouts to be known.

2.7 Data Preparation and Preliminary Analysis

The next section describes how data were prepared for analysis and the analyses performed to answer the research questions. Descriptive statistics were used to calculate levels of local and global processing among the sample. From the assessment paradigm, each participant received a local and global processing score. This means that each person had a global score and a local score for pre-training and post-training. If a participant made an erroneous response during

the experiment, this was removed from the data. An erroneous response would have been an opposite response to the one intended (e.g., pressing response button 1 instead of 2 or vice versa).

To test for local processing bias in individuals with Asperger syndrome, a comparison of local/global processing levels between groups was completed using t-tests. Global processing style gains in adults with and without Asperger syndrome were statistically analysed using 2-way ANCOVA: group (Asperger syndrome, control) x training condition (global, attentional control), controlling for Time 1 processing scores as the covariate.

2.8 Data preparation

Data were dealt with as follows: 1) only correct responses have been included, 2) only scores between the range of 200 and 2000 milliseconds were included, and 3) the median score was extracted for each stimuli for each participant, which reduces the influence of outliers. The range of 200 and 2000 milliseconds is a standard method which means that responses that were made too quick to be "real" responses to the stimuli are removed, and any that are too long (and so might be where the participant wasn't concentrating) are removed. Within the local processing pre-test one participant produced a median score of over 2000 milliseconds and is deemed too long for a "real" response. The participant was part of the Asperger syndrome group assigned to the attentional control condition. The participant's local pre-test score was removed from the data but, a global pre-test score was intact. Reviewing the participant's data it suggested the person may have experienced some initial difficulty comprehending the task when identifying local stimuli.

2.9 Outliers

Outliers for the data were deduced by visually inspecting histograms which indicated outliers were presented within the data sets. Outliers were any responses two standard deviations from the median response time for each individual type of Navon (1977) stimuli. For each pre- and post-test, four different types of stimuli were randomly presented four times, for both the local and global processing tasks. Any of the four responses two standard deviations from the median were removed and the median score deduced for each individual stimuli. A median score was calculated for each type of stimuli: with an overall local and global mean score calculated from the four median scores.

2.10 Normality tests

The study's dependent variable of participant's processing styles was measured by the pre-test and post-test computer paradigm. Normality assumptions for the data were deduced by visually inspecting histograms which indicated all data sets were normally distributed. To further test normality assumptions z-scores calculated from skewness and kurtosis statistics were reviewed (Field, 2009). Inspecting z-scores was used, as the Kolmogorov-Smirnov and Shapiro-Wilks tests can be overly conservative when estimating the normality of a distribution (Field, 2009). The skewness and kurtosis z-scores were calculated using the following equations (where S = skewness, K = kurtosis, and SE = standard error):

$$\text{Z skewness} = \frac{S - 0}{\text{SE skewness}} \qquad \text{Z kurtosis} = \frac{S - 0}{\text{SE kurtosis}}$$

The results of these calculations are reported in Table 2. As the sample had less than 40 participants, z-scores greater than 1.96 (i.e., $p < .05$) were interpreted as being indicative of a non-normal distribution (Field, 2009). As can be seen from Table 4 (see Section 3.3 Main Analysis), the data met normal distribution assumptions, and accordingly parametric data analyses were employed.

2.11 Homogeneity of Regression

Homogeneity of variance assumptions need to be fulfilled in order to conduct ANCOVA. The Levene's test was not significant for the pre-test scores, local pre-test ($F(3, 35).732$, $p = .540$) and global pre-test ($F(3, 3\ 6).373$, $p = .773$) and indicates the variances of the four groups are roughly equal and normally distributed: fulfilling homogeneity of regression assumptions.

2.12 Quantitative Analysis

The following statistical analyses were used to test each hypotheses:

2.12.1 Research question 1.

Is there a difference in local/global processing bias between typically developing adults and adults with Asperger syndrome? When naming local or global letters that have a differing letter at both the local and global level.

A t-test was used to compare the scores on the processing styles for those with Asperger syndrome and typically developing participants. This test assumes that the two groups are from populations of equal variances and fulfils normality of data assumptions.

Table 2 *Normality Data for Study Variables According to Processing Style*

	Asperger syndrome								Typically Developing							
	Training (n = 10)				Attentional Control (n = 9 local / 10 global)				Training (n = 10)				Attentional Control (n = 10)			
	M	SD	Skew. z-score	Kurt. z-score	*M*	SD	Skew. z-score	Kurt. z-score	*M*	SD	Skew. z-score	Kurt. z-score	*M*	SD	Skew. z-score	Kurt. z-score
Local Pre-test	966.10	203.17	-0.36	-0.31	855.82	203.17	0.218	-0.22	863.79	171.43	0.40	-1.24	911.08	201.02	0.87	-0.30
Global Pre-test	916.24	196.11	0.85	-0.32	932.17	185.21	0.20	-0.60	897.88	178.53	-0.28	-0.18	904.99	180.35	-1.36	1.05
Local Post-test	699.70	78.88	-1.13	0.10	669.25	136.61	-0.84	0.46	728.60	140.43	0.58	-1.05	640.69	106.45	0.95	0.67
Global Post-test	637.45	93.96	-0.52	-1.09	616.96	-0.16	-1.26	-0.46	733.79	79.93	0.03	-1.01	606.53	99.02	-0.40	-0.49

Note. Skew. = Skewness; Kurt = Kurtosis; ∗ significant at p < .05; ∗∗ significant at p < .01; ∗∗∗ significant at p. < .001.

2.12.2 Research question 2. Can computerised training paradigms enhance global processing style in adults with Asperger syndrome? When compared to adults with Asperger syndrome receiving attentional control condition, and typically developing adults receiving either global training or attentional control condition.

To compare the changes in global and local processing score of the respective groups a 2 (Group: Asperger syndrome or typically developing) x 2 (Training: attentional control or global) ANCOVA was conducted. Global or local processing score at Time 1 acted as the covariate within the analysis.

2.13 Summary

This chapter described the participant characteristics and procedure employed by this study. The measures used within the screening process have been outlined and the testing described to analyse the research questions. Two groups of participants (Asperger syndrome group and typically developing controls) were recruited from Asperger East Anglia and the local community. Half of each group then received either a computerised global training paradigm or an attentional control condition. Once data had been collected parametric analysis were used to determine whether confounding variables differed significantly between groups. Finally, outliers were removed to ensure data fulfilled normal distribution assumptions and enabled parametric data analysis to be undertaken.

Chapter Three

Results

3.1 Introduction

The aim of this chapter is to outline the main findings of the study. The chapter will then summarise the findings regarding the study's main hypotheses and some exploratory analyses relating to these. Once data had been collected parametric analysis were used to determine whether processing styles differed between people with and without Asperger syndrome. Further analysis was then conducted to establish if global processing style had been enhanced in people with Asperger syndrome, when compared to people with Asperger syndrome receiving attentional control or typically developing adults either receiving global training or the attentional control condition.

3.2 Participant Demographics

Prior to covering the main analyses, it needs to be established if significant between group differences are present, and if so, potentially accountable for any observable differences in processing style between people with and without Asperger syndrome. Table 3 shows a breakdown of the participant characteristics for each of the study's four groups. One-way between-groups ANOVA highlighted no significant group differences in terms of age $F(3, 36) = .294$, $p = .829$, IQ $F(3, 36) = .656$, $p = .585$, education $F(3, 36) = .8.15$, $p = .494$, and handedness $F(3, 36) = .167$, $p = .288$, confirming no significant differences between groups. As expected, a one-way between-groups ANOVA conducted on AQ-10 score confirmed a significant difference between Asperger

syndrome and typically developing groups $F(3, 36) = 44.088$, $p < .000$. Post hoc comparisons, using the Sidak method, revealed there was no significant

Table 3 *Participant Demographics According to Group*

	Asperger Syndrome		Typically Developing	
	Global Training (n = 10)	Attentional Control (n = 10)	Global Training (n = 10)	Attentional Control (n = 10)
Gender				
Male	6	6	6	6
Female	4	4	4	4
M Age (SD)	30.8 (12.21)	30.9 (9.85)	33.4 (7.78)	34.2 (10.13)
M IQ (SD)	122.2 (21.27)	116.4 (18.67)	114 (6.8)	113.9 (8.77)
Handedness				
Right	8	10	9	7
Left	2	0	1	3
M handedness (SD)	.8 (.42)	1.0 (0)	.9 (.32)	.7 (.48)
M AQ-10* (SD)	7.5 (1.84)	7.9 (2.28)	0.7 (.95)	1.8 (1.81)
Education				
None	0	2	0	0
GCE level	1	1	1	0
Diploma	2	2	2	2
A level	1	1	2	3
Undergraduate	4	2	2	3
Postgraduate	2	2	3	2
Doctoral	0	0	0	0
M education (SD)	3.4 (1.35)	3.6 (1.9)	3.4 (1.43)	3.5 (1.08)

Note. ∗ Statistically significant difference on this variable across groups. Education scoring = none 0, GCE 1, Diploma 2, A level 3, Undergraduate 4, Postgraduate 5, Doctoral 6. Handedness scoring = Left 0, Right 1.

difference in AQ-10 score between the respective Asperger syndrome groups (training *M* AQ-10 score = 7.5, attentional control *M* AQ-10 score = 7.9, *p* >0.05) or the two typically developing groups (training *M* AQ-10 score = 0.8, attentional control *M* AQ-10 score = 1.8, *p* >0.05), while both Asperger syndrome groups differed significantly from both typically developing groups (p < .000).

3.3 Main Analysis

3.3.1 Research Question 1. Primary: 1) Is there a difference in local/global processing bias between typically developing adults and adults with Asperger syndrome, when naming local or global letters that have a differing letter at both the local and global level.

The first research hypothesis predicted that adults with Asperger syndrome will demonstrate local processing bias, and global processing deficits, when compared with a typically developing control group. Thus, adults with Asperger syndrome will perform better in local processing trials, with typically developing controls predicted to have significantly superior performance in global processing trials. An overview of all groups processing scores is provided in Table 4.

Turning to consider the pre-training scores of the four groups, quite a mixed picture is presented by Table 4 as to whether people with or without Asperger syndrome are faster at local and/or global processing. When looking at overall group processing scores (see Table 4) the picture becomes clearer. The results suggest the typically developing group were faster at both local and global

processing pre-training, when compared to like matched people with Asperger syndrome.

Table 4 *Participant Processing Scores According to Group and Condition*

	Asperger Syndrome			Typically Developing		
	Global Training *M* (SD) (*n* = 10)	Attention Control *M* (SD) (*n* = 9)	Marginal *M* (SD) (*n* = 19)	Global Training *M* (SD) (*n* = 10)	Attentional Control *M* (SD) (*n* = 10)	Marginal *M* (SD) (*n* = 20)
Local Pre-test Score	968.49 (199.00)	855.82 (119.81)	915.87 (171.82)	863.79 (171.43)	911.08 (201.02)	887.43 (183.44)
Global Pre-test Score	916.24 (196.11)	932.24 (185.13)	952.38 (221.42)	897.88 (178.53)	904.99 (180.35)	901.43 (174.69)
Local Post-test Score	699.70 (78.88)	669.25 (136.61)	685.28 (107.93)	728.60 (140.42)	640.69 (106.45)	684.64 (129.39)
Global Post-test Score	637.45 (93.96)	618.67 (136.83)	628.60 (113.26)	733.79 (79.93)	607.60 (97.71)	670.69 (108.35)
Local Change Score	-268.79 (162.88)	-186.57 (161.55)	-229.84 (163.23)	-135.19 (87.08)	-270.39 (130.50)	-202.79 (128.33)
Global Change Score	-278.79 (155.36)	-313.47 (137.97)	-295.22 (144.38)	-164.09 (119.55)	-297.36 (135.30)	-230.74 (144.84)

Note. All values are milliseconds; M local and global change score was calculated by subtracting the respective post-tests scores from the pre-test scores; attention control *n* = 9 for local but *n* = 10 for global.

The first hypothesis explores differences between people with and without Asperger syndrome, irrespective of whether they received training or not. Although people with Asperger syndrome were slower at both local and global processing, it needs to be explored if these observed differences are significant. The pre-training processing scores for the two groups, people with Asperger syndrome and typically developing (see Table 4), were compared via an independent samples *t*-test. No significant difference between processing styles were found between groups for local processing, t (37) = .46, p =.65 (two tailed), or global processing, t (38) = .81, p = .43 (two tailed). Thus, we can accept the null hypothesis and conclude no significant difference exists in local or global processing between typically developing adults and adults with Asperger syndrome, when naming local or global letters that have a differing letter at both the local and global level.

When reviewing the statistical analysis used for Hypothesis 1, the use of a *t*-test warrants further consideration. By using an independent samples *t*-test the significant difference in local and global processing styles between adults with and without Asperger syndrome has been explored. The first research hypothesis, however, specifically explores differences in processing bias and this question cannot be answered using such statistical analysis. A *t*-test informs us about differences in processing style but is unable to report on the predicted local processing bias or global processing deficits for people with Asperger syndrome, when compared with a typically developing control group. In order to sufficiently answer such a hypothesis a two-way ANOVA would need to be conducted to explore if a significant interaction exists between groups and processing styles.

3.3.2 Research Question 2. Primary: 2) Can computerised training paradigms enhance global processing style in adults with Asperger syndrome? When compared to adults with Asperger syndrome receiving attentional control condition, and typically developing adults receiving either global training or attentional control condition.

It is hypothesised that for Asperger syndrome and typically developing groups in the global training condition, that global processing score will decrease, when compared to groups in the attentional control condition. To compare the changes in global processing score of the respect groups a 2 (Group: Asperger syndrome or typically developing) x 2 (Training: attentional control or global) ANCOVA was conducted. Global processing score at Time 1 acted as the covariate within the analysis.

The covariate, global pre-test score, was significantly related to global processing post-test score, $F(3, 36) = 31.547$, $p = .000$, $r = 0.47$. Considering the main effect of training, those who received training scored significantly higher than those in the attention control condition at post-test, meaning that the training group took significantly longer to respond to the stimuli, $F(3, 36) = 10.738$, $p = .002$, $\eta^2 = 0.235$. In other words, the attention control condition were significantly faster at responding to stimuli than the training group at post-test. Ignoring training, typically developing adults took significantly longer to respond to the stimuli than those with Asperger syndrome, $F(3, 36) = 4.860$, $p = .034$, $\eta^2 = 0.122$ (see Table 5).

Using Cohen's (1988) measure of effect size, training produced a large effect size ($\eta^2 = 0.235$) on global processing, while the differences between those with

Asperger syndrome and typically developing adults was associated with a medium to large effect size (η^2 = 0.122). Turning to consider the Training X Group interaction, this was not significant, $F(1, 35) = 4.083$, $p = .051$, η^2 = 0.104 (see Table 5), although the effect size was medium to large. Considering the strength of the effect size, post hoc testing using the Sidak method was undertaken to find out which groups differ (see Table 6).

The significant results for hypothesis 2 were not in line with expectations. It is hypothesised that for those with Asperger syndrome and the typically developing group in the global training condition, that global processing will get significantly faster, when compared to groups in the attentional control condition. Conversely, the significant improvement in global processing speed was observed for the attentional control condition as opposed to the training condition. With global pre-test score acting as a covariate, the Sidak corrected post hoc comparisons revealed significant differences in global processing between the typically developing group receiving training and the three other groups (see Table 6; $p < .05$). Meaning, those typically developing people receiving training became significantly slower at global processing than the other groups. Moreover, those people receiving the attentional control condition became significantly faster at identifying global stimuli than those typically developing people receiving training at $p < .01$ (see Table 6). This result is the opposite of the expected result and will be discussed further in the Discussion (see section 4).

Table 5. *Univariate ANCOVA analysis for Post-Test Global Processing Scores According to Group and Condition, with Pre-Test Global Processing Scores as a Covariate*

Source	Type III Sum of Squares	Df	*M* Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Corrected Model	277056.405[a]	4	69264.101	11.845	.000	.575	47.379	1.000
Intercept	176162.636	1	176162.636	30.125	.000	.463	30.125	1.000
Global pre-test score	184477.538	1	184477.538	31.547	.000***	.474	31.547	1.000
Training or Control	62791.230	1	62791.230	10.738	.002**	.235	10.738	.890
Group AS or TD	28419.811	1	28419.811	4.860	.034*	.122	4.860	.573
Training or Control Group AS or TD	23874.297	1	23874.297	4.083	.051	.104	4.083	.502
Error	204669.439	35	5847.698					
Total	17526823.453	40						
Corrected Total	481725.843	39						

AS = Asperger Syndrome; TD = Typically Developing; AC = Attentional Control; * significant at p < .05; ** significant at p < .01; *** significant at p. < .001.

Table 6. *Post hoc testing using Sidak method for Post-Test Global Processing Scores According to Group and Condition*

Dependent Variable	Group and Condition	Group and Condition	*M* Diff.	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Global Post-Test Score	AS Training	AS AC	30.6255	34.498	.944	-65.561	126.811
		TD Training	-102.810	34.218	.029*	-198.215	-7.405
		TD AC	25.886	34.206	.974	-69.485	121.257
	AS AC	AS Training	-30.625	34.498	.944	-126.811	65.561
		TD Training	-133.434	34.668	.003*	-230.095	-36.774
		TD AC	-4.738	34.598	.004*	-101.203	91.726
	TD Training	AS Training	102.810	34.218	.029*	7.405	198.215
		AS AC	133.434	34.668	.003*	36.774	230.095
		TD AC	128.696	34.201	.004*	33.337	224.055
	TD AC	AS Training	-25.886	34.206	.974	-121.257	69.485
		AS AC	4.738	34.598	1.000	-91.726	101.203
		TD Training	-128.696	34.201	.004*	-224.055	-33.337

Note. *M* Diff. = Mean Difference; Std. Error = Standard Error; Sig. = Significance; AS = Asperger Syndrome; TD = Typically Developing; AC = Attentional Control; ∗ significant at $p < .05$.

3.4 Subsidiary Analysis

The significant change in global processing style for people with and without Asperger syndrome unexpectedly arose from the attentional control condition. Accordingly, it appeared appropriate to repeat the statistical analysis performed

to test hypothesis 2 to determine if similar changes in local processing were observable.

The covariate, local pre-test score, was significantly related to local processing post-test score, $F(3, 35) = 21.999$, $p = .000$, $r = 0.39$ (see Table 7). There was no significant difference in local processing style between those who had received training and those in the attention control condition at post-test, $F(3, 35) = 2.313$, $p = .138$, ($\eta^2 = 0.064$ (see Table 7). Ignoring condition, there was no significant difference on post-test local processing performance for those with AS compared to those who were typically developing, $F(3, 35) = .122$, $p = .729$, $\eta^2 = 0.004$. The training produced a medium effect size ($\eta^2 = 0.064$) on local processing, while the effect of group produced a small effect size ($\eta^2 = 0.004$) (Cohen, 1988). The Training X Group (Asperger syndrome or typically developing) was not significant, $F(3, 35) = 4.091$, $p = .051$, $\eta^2 = 0.107$, although the effect size was medium to large.

As completed for global processing, post hoc testing using the Sidak method was undertaken to find out which groups differ on local processing post training (see Table 8). The results indicate no significant difference in local processing for any groups at post-test ($p > .05$), with local pre-test score acting as a covariate.

Table 7. *Univariate ANCOVA analysis for Post-Test Local Processing Scores According to Group and Condition, with Pre-Test Local Processing Scores as a Covariate*

Source	Type III Sum of Squares	df	*M* Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Corrected Model	233478.289[a]	4	58369.572	6.743	.000	.442	26.971	.984
Intercept	126161.927	1	126161.927	14.574	.001	.300	14.574	.960
Local pre-test score	190439.340	1	190439.340	21.999	.000***	.393	21.999	.995
Training or Control	20020.885	1	20020.885	2.313	.138	.064	2.313	.315
Group AS or TD	1058.390	1	1058.390	.122	.729	.004	.122	.063
Training or Control Group AS or TD	35416.975	1	35416.975	4.091	.051	.107	4.091	.502
Error	294327.730	34	8656.698					
Total	18825012.359	39						
Corrected Total	527806.019	38						

AS = Asperger Syndrome; TD = Typically Developing; AC = Attentional Control; * significant at p < .05; ** significant at p < .01; *** significant at p. < .001.

Table 8. *Post hoc testing using* Sidak *method for Post-Test Local Processing Scores According to Group and Condition*

Dependent Variable	Group and Condition	Group and Condition	*M* Diff.	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Local post-Test Score	AS Training	AS AC	-16.441	43.903	.999	-139.064	106.182
		TD Training	-72.475	42.634	.462	-191.553	46.603
		TD AC	35.118	41.920	.957	-81.967	152.203
	AS AC	AS Training	16.441	43.903	.999	-106.182	139.064
		TD Training	-56.034	42.755	.735	-175.451	63.384
		TD AC	51.559	43.030	.806	-68.625	171.743
	TD Training	AS Training	72.475	42.634	.462	-46.603	191.553
		AS AC	56.034	42.755	.735	-63.384	175.451
		TD AC	107.593	41.820	.085	-9.213	224.399
	TD AC	AS Training	-35.118	41.920	.957	-152.203	81.967
		AS AC	-51.559	43.030	.806	-171.743	68.625
		TD Training	-107.593	41.820	.085	-224.399	9.213

Note. M Diff. = Mean Difference; Std. Error = Standard Error; Sig. = Significance; AS = Asperger Syndrome; TD = Typically Developing; AC = Attentional Control; ∗ significant at $p < .05$.

3.5 Summary

When testing the study's first hypothesis, there was no significant difference in local or global processing between typically developing adults and adults with Asperger syndrome, when naming local or global letters that have a differing letter at both the local and global level. Thus, the null hypothesis would be

accepted of no local processing bias being present for people with Asperger syndrome or global processing superior for typically developing adults. The study's second hypothesis, however, was partly supported. The main effect of training on global processing, indicated that people who received training scored significantly higher than those in the attention control condition at post-test, meaning the training group took significantly longer to respond to the global stimuli, while the attention control group were significantly faster; this is the reverse of what was expected. The effect of group revealed typically developing adults took significantly longer post-test to respond to global stimuli than those with Asperger syndrome. Neither the main effects of training or group produced significant results for local processing.

Chapter Four

Discussion

4.1 Introduction

This chapter will consider the implications of the study's results in greater detail. After restating the aims of the research, it will discuss the findings relating to the each of the two hypotheses. Following a critical evaluation of the study's methodological strengths and limitations, the chapter will then discuss the theoretical and clinical implications of its findings. The chapter will then conclude with some suggestions for future research relating to Weak Central Coherence Theory (WCCT; Frith & Happé, 1994) and other theories of information processing for people with Asperger syndrome.

4.2 Study aims

The study aimed to investigate a local processing bias in adults with Asperger syndrome. A further aim was to see if a computerised training paradigm could significantly improve the ability of people with Asperger syndrome to process information pertaining to global processing. To explain how people with Asperger syndrome make sense of information the WCCT (Happé & Frith, 2006) suggested a preference for focusing on finer details is typical for people with the condition, but at the expense of integrating pieces of information into a coherent whole (Frith & Happé, 1994). Thus, the WCCT suggests people with Asperger syndrome have what is referred to as a local processing bias, and focus on piecemeal bits of information (Happé & Frith, 2006). By contrast, typically developing individuals are able to process

information in its wider context (Hill & Frith, 2003), and display a tendency to look at the bigger picture. The WCCT account of information processing has been updated. Rather than an absence of global processing ability for people with Asperger syndrome, refinements to the theory emphasised a reduced ability to integrate information to form a whole (Happé & Booth, 2008). The emergence of research evidencing global processing for adults with Asperger syndrome (Plaisted et al., 1998; Rondan & Deruelle, 2007; Nakano et al., 2012) prompted the WCCT to propose a local processing bias as a dominant cognitive style in Asperger syndrome, but global processing becomes possible when people are overtly directed to do so. (Happé & Frith, 2006).

As the WCCT (Frith & Happé, 1994) remains a major theory of information processing within autism and Asperger syndrome literature, the aim of the study was to clarify if a local processing bias existed for people with Asperger syndrome, and additionally whether global processing could be enhanced for this population. To understand if certain information processing styles are typical for people with Asperger syndrome, adults with a diagnosis of Asperger syndrome were compared with typically developing peers on measures of processing style. Processing styles were investigated for all adults with and without Asperger syndrome using a computerised pre-test paradigm. By using an experimental design, exploring processing styles before and after training, it was possible to determine if detectable changes in processing style were caused by the computerised training paradigm processing styles. With these aims in mind, the next section will consider the findings relating to the hypotheses.

4.3 Brief Summary on Findings

4.3.1 Hypothesis 1. The primary hypothesis predicted a difference in local/global processing bias between typically developing adults and adults with Asperger syndrome, when naming local or global letters that have a differing letter at both the local and global level. Given the previous research findings, it was hypothesised that adults with Asperger syndrome will demonstrate local processing bias, and global processing deficits, when compared with a typically developing control group. Inconsistent with this prediction, no significant difference was found in either local or global processing styles between people with Asperger syndrome and typically developing peers. The result fits with research highlighting inconsistent findings about a local processing bias for people with Asperger syndrome. Additionally, the results indicated that people with Asperger syndrome can overcome any proposed local bias in processing when attention requires a typical global processing precedence effect (Plaisted, Swettenham, & Rees, 1999).

One explanation for the inconsistent results may be that different types of global processing exist. Although subject to debate (Behrmann et al., 2006), global processing is regarded as processing the highest level of hierarchical stimuli (Rondan & Deruelle, 2007). Conversely, configural processing is seen as processing of the interspatial relations between elements. Rondan and Deruelle (2007) suggest that people with Asperger syndrome will display a global preference for HLs but a local preference for stimuli emphasising inter-spatial relations. As this study used HLs, it is reasonable to suppose that intact global processing was evident for adults with Asperger syndrome.

4.3.2 Hypothesis 2. The second primary hypothesis explored if a computerised training paradigm could enhance global processing style in adults with Asperger syndrome. Any gains in global processing for people with Asperger syndrome receiving global training was compared to adults with Asperger syndrome receiving attentional control condition, and typically developing adults receiving either global training or attentional control condition. It was hypothesised that for Asperger syndrome and typically developing groups in the global training condition, that global processing would get faster, when compared to groups in the attentional control condition. A significant improvement in global processing was evident for people with Asperger syndrome receiving the attentional control condition when compared to the typically developing adults and people receiving global training. This is the reverse of what was hypothesised.

The WCCT hypothesised (Happé & Frith, 2006) global processing could be performed by people with Asperger syndrome when they are explicitly directed to do so. The study's finding supported the potential for global precedence in adults with Asperger syndrome (Hayward et al., 2012). The potential for augmenting intact global processing for people with Asperger syndrome has not been incorporated into the global-deficit-driven WCCT. Any future revisions to the theory might consider what happens to processing styles in people with Asperger syndrome, if they are regularly instructed to undertake tasks orientated towards global processing (Caron, Mottron, Berthiaume & Dawson, 2006).

The Empathising-Systematising theory (Baron-Cohen, 2009) proposed that people with Asperger syndrome use local processing and attention to detail to

make sense of the world but can see the whole picture, given time. By systematising, people intuitively figure out the rules of a system, which some people with Asperger syndrome expressed during the experimental computer test of processing styles. Although the global and local trials were random some people with Asperger syndrome commented ‘‘I can work out what’s coming next’’, suggesting people were trying to figure out the rules of a system in order to understand a system and predicts its behaviour (Baron-Cohen, 2003a). Thus, people with Asperger syndrome may have understood the system of how Navon (1977) HLs are presented at either a local or global level. If so, their performance and ability to improve both local and global processing can be explained in terms of understanding a system. Additionally, Caron, Mottron, Berthiaume and Dawson (2006) indicated that people with Asperger syndrome are better equipped to employ either a local or global orientated search strategy. Thus, suggesting greater perceptual versatility for people with, rather than without, Asperger syndrome (Hayward et al., 2012). However, the Empathising-Systematising theory proposed each system is slightly different and creates an inability to generalise information. Thus, the Empathising-Systematising theory would argue the augmenting of global processing in this study by people with Asperger syndrome is specific to the task.

4.4 Strengths and Limitations of the Study

The purpose of this section will be to consider the strengths and limitations of the current study. While this study contained several strengths, the conclusions that can be made from its results are limited by some methodological issues. The section will also look to highlight certain methodological issues that need to be

taken into account when conducting future research on WCCT, and when using experimental computer paradigms.

4.4.1 Methodology. In the end a pragmatic approach was adopted to try to achieve a standardised test environment for the study. Ideally, to truly standardise test conditions, all participants would have been seen at the same standardised test site, in the same room and at the same work station. Such a venue was unavailable and realistically the best option was to use an office free from distraction at two different Asperger East Anglia premises. Two more typically developing participants were tested at their homes when compared to the Asperger syndrome group. To ensure a similar test environment was created, all participants were seated in a distraction free room facing a plain wall. Without taking such measures to standardise different test venues the introduction of distraction and error could easily have occurred. Unfortunately, it is not possible to suggest all bias was removed from the test conditions as the researcher was aware of the experimental aims.

4.4.2 Design. This study employed a 2 (Group: Asperger syndrome or typically developing) x 2 (Training: attentional control or global) x (2 (Time: 1 or 2) mixed experimental design *x S*) yielding four groups. The design was chosen because the study had two training conditions and tests processing at time 1, pre-test, and time two, post-test. The study compared the processing styles of people with and without Asperger syndrome. Two groups of participants, Asperger syndrome and typically developing control, were randomly assigned to two conditions, global training or attentional control. The groups were compared using a one-way between groups ANOVA and this ensured groups were well

matched on several variables: IQ, age, handedness and highest education. Closely matched groups ensured any observed differences could reliably be attributed to the independent variable, in this case presence or absence of Asperger syndrome. It also suggests participants were sufficiently randomised to the respective groups. Thus, the design appeared to be appropriate to answer the research questions posed by this thesis.

Importantly, the design also allowed causation to be explored within the experimental paradigm. The design permitted ANCOVA to be conducted which reduces within-group error variance by including covariates to explain some unexplained variance (Field, 2009). By using respective pre-test local and global processing scores as a covariate more of the variability within the experiment is explained and error variance is reduced. As it transpired, in the current findings the covariate of local pre-test score explained thirty six percent and global pre-test thirty eight percent variability of local and global post training scores respectively.

4.4.3 Recruitment and sample size. At first glance the sample size of the study might appear modest. Comparative studies, contained within the Literature Review (Section 1.4), had not reported power calculations in determining sample sizes. The present study had a sample size representative of reviewed studies reporting sufficient power, as in the case of Bölte et al. (2007). The power of the current study was sufficient to reliably permit detectable changes in the dependent variable to be observed (Clark-Carter, 1997).

The global training paradigm used in the current study was doubled in length of that used by Hoppitt (2012). By reporting effect size (ES) the degree of

observed change can be deduced irrespective of sample size. The main effect of training was not significant for local processing with $F(3, 35) = 2.313$, $p = .138$, $\eta^2 = 0.064$ but was for global processing, where training led to slower response times $F(3, 36) = 10.738$, $p = .002$, $\eta^2 = 0.235$ compared to those receiving an attentional control condition. The result suggests our attentional control condition significantly improves the speed of global processing, but not local processing, compared to global training. The original Hoppitt (2012) study employed a local and global training paradigm with an undergraduate sample. It is reasonable to suggest the demographic properties of the undergraduate population may differ substantially in age to the current sample, given all four groups tested had a mean age over thirty. Debatably, a younger undergraduate population possess greater flexibility in their processing style and are more receptive to training. Thus, may have been more receptive to the global training than the current sample.

Within the *a priori* power calculations reported (see Section 2.3.2 Sample size and power calculations) it is noteworthy that the population effect size was estimated based on the previous research by Hoppitt (2012). Therefore, the power of the test assumed a population effect size to be exactly equal to the effect size observed within the current sample (O'Keefe, 2007). After collecting data, a sample effect size is calculated and referred to as 'observed power' within SPSS output. Power calculations are then calculated on the basis of the significance criterion used, sample size that was used, and population effect size equal to the actual sample. Although, it is important to note that SPSS treats the obtained sample effect size as the population effect size (O'Keefe, 2007). Given the non-significant result for hypothesis one it is possible to infer that the

observed statistical power is low because the population effect is not equal to the sample effect.

The response ratio for recruitment was approximately calculated based on the number of information packs disseminated and those actually returned. It is estimated a response rate of approximately twenty five percent was achieved for the clinical group. For the non-clinical groups a response rate of sixty seven percent has been gauged. Several explanations may exist for the discrepancy in the response rates between the clinical and nonclinical groups. Firstly, the awareness presentations delivered to Asperger East Anglia support groups provided those attending with their first exposure to the study. It is reasonable to suppose that people's initial enthusiasm could wane, given time to reflect. Participants from the control group largely learnt about the study independently which suggests some internal motivation on their part to be involved in the study. Secondly, a high proportion of people with Asperger syndrome have co-morbid mental health needs (Donoghue, Stallard, & Kucia, 2011; Lugnegard, Hallerbäck, & Gillberg, 2011; Skokauskas & Gallagher, 2010). It is reasonable to suggest co-morbidity makes it more challenging for people with Asperger syndrome to take part in face to face research.

The study relied on participants confirming their diagnosis of Asperger syndrome. The study took a pragmatic approach to screening and employed the AQ-10 (Allison et al., 2012) to assess level of autistic-like traits for all participants. The AQ-10 is a screening tool for autistic like traits and does not provide confirmatory evidence of the presence or absence of Asperger syndrome. Similar studies have employed more rigorous procedures using reliable and

validated diagnostic tools or taking extensive participant histories (Jolliffe & Baron-Cohen, 1997, 1999, 2000, 2001a & 2001b) to confirm the diagnosis in accordance with DSM-IV (APA, 1994) or ICD-10 (WHO, 1993). Some studies even employed the diagnostic tools of the Autism Diagnostic Observation Schedule (ADOS) (Lord et al., 1989) and the Autism Diagnostic Interview-Revised (ADI-Revised) (Lord, Rutter, & Le Couteur, 1994) to reaffirm an existing diagnosis of Asperger syndrome (Behrmann et al., 2006: Katsyri, Saalasti, Tiippana, von Wendt, & Sams, 2008). Thus, a more robust and rigorous screening procedure for confirming a diagnosis of Asperger syndrome was possible. The decision to adopt the AQ-10 was made to reduce demands on participants where possible. As it transpired, recruitment for the study was challenging enough, and further screening demands may have resulted in a problem recruiting the required quota of participants.

The intention was for recruitment in the study to reflect the prevalence of autism being four times greater in men (Center for Disease Control and Prevention, 2010). The ratio finished with three males recruited for every two females: or six males and four females per group. Although many studies have tried to adhere to the stipulated gender ratios within recruitment, it has not been universally followed. Katagiri et al. (2013) had a higher ratio of female participants and Bölte et al. (2007) only recruited males. The two studies noted, and to a lesser degree this study, raises the possibility that these were atypical samples. Current debate, however, suggests that the gender ratio within Asperger syndrome is narrowing. In part, the suggestion of revised gender ratios has been attributed to increased awareness of the covert behaviour displayed by females with undiagnosed Asperger syndrome (Charman & Gotham, 2013). Thus, the

gender recruitment ratio within this thesis, may in time, become representative of the gender ratios within Asperger syndrome populations.

4.4.4 Stimuli of Navon (1977) hierarchical letters. The Hierarchical Letter (HL; Navon, 1977) measure is proposed to permit both local and global processing to be measured. Alternatively, other stimuli used in research arguably orientate attention towards finer details of tasks, such as the Embedded Figures Test (Wang et al., 2012). Previous research results varied from demonstrating a significant local processing bias in high-functioning autism and Asperger syndrome (Behrmann et al., 2006; Katagiri et al., 2013), to comparative groups showing a preference for global processing (Bölte et al., 2007; Rondan & Deruelle, 2007). The current study evidenced both intact local and global processing for adults with Asperger syndrome. As noted previously, (See Section 1.4.4) HLs show intact global processing in Asperger syndrome because they test both local and global processing. Given the equal opportunity to demonstrate local or global processing preferences, no significantly different processing preference was shown by any Asperger syndrome or typically developing group.

The careful construction and display of HLs tried to ensure attentional bias was not orientated towards either local or global stimuli (Kimchi, 1992). Conversely, the forced-choice between two responses could have prevented local processing bias being significantly different (Han, Wang and Zhou, 2004). With only two options to choose from ‘Do you see an L or a H’ it limited the range of responses and may not be representative of everyday processing involving an array of stimuli to integrate into a coherent whole. The HL stimuli were also

limited to four letter configurations, consisting of the letters L, H, F and T. Letter choice was restricted to letters with defined straight edges, to ensure the big global letters accurately represented the target letters of L, H, F and T. If people had a great affinity towards any of the four configurative letters it may have influenced their attentional bias.

Other plausible explanations into the lack of observed differences in processing styles between people with and without Asperger syndrome will be discussed. The absence of a local processing bias for people with Asperger syndrome may result from the 'infinite' exposure time of the Navon (1977) HL. Arguably the pre-test and post-test provided a measure of capacity to perform local and global processing given time to do so, as opposed to an explicit inclination towards a style of processing. Alternatively, by displaying Navon (1977) HLs with a fixed exposure time a processing bias may become measurable. For example, if each HL trial had both a local and global letter that could be detected as a potential response it becomes viable to infer a processing inclination is being measured: rather than local and global processing capacity. After displaying HLs, for approximately 500-750 milliseconds, a question could be posed of 'What letter did you see first?' With an array of potential responses discriminating between local and global features of a HL trial, and both accuracy and response time recorded, a more valid measure of processing bias could be attained.

An alternative explanation for the global processing gains observed in people with Asperger syndrome will consider additional factors important in processing HLs in our paradigm. The task of identifying HLs may require a degree of

emotional inhibition from participants because the task asks people to do something atypical of everyday processing. It is reasonable to suggest that people are not typically required to identify a letter outline that is made up of a suitable arrangement of little letters. As a consequence, and frequently observed in the Stroop task (Stroop, 1935), people say what they expect to see: in our paradigm a letter that represents the local stimuli. Essentially, in order to identify the larger letter, made up of little letters, people are required to suppress their instinctual response. Participants with Asperger syndrome may be better at inhibiting an impulsive response (i.e., identifying the local letter when the target letter is at the global level) even after several repetitions of the task (Gonzalez, Martin, Minshew & Behrmann, 2013). Additionally, if a relationship exists between emotional inhibition and IQ, our particularly high functioning Asperger syndrome groups may have atypically superior impulse inhibitors compared to less able peers and other Asperger populations.

As no observable differences in processing style were detected between groups, the validity of Navon HLs as a measure of local and global processing should be discussed. It is possible that HLs fail to unearth the qualitative processing difference that may exist between people (Gerlach & Krumborg, 2014) with and without Asperger syndrome. Miller, Odegard and Allen (2014) implied that when processing global information weaker neurological connections are created for people with Asperger syndrome and thus global stimuli is more inaccessible for them. It is further proposed that to test the qualitative global processing differences evident in Asperger syndrome then additional processing components, such as rule-based processing or executive functioning, need to be explored in conjunction with tests of WCC to show

cognitive differences in global processing for people with the condition (Miller, Odegard & Allen, 2014). Although, the causal relationship between WCC and executive dysfunction for people with Asperger syndrome would still require further disentangling.

4.4.5 Training Paradigm. In essence the range of scores proposed on the computerised pre-test and post-test was quite large. The range of 200 and 2000 milliseconds is a standard method, measuring "real" responses to the stimuli and offers a range of 1800 milliseconds. After removing outliers, responses two standard deviation to the mean for each HL, the range of scoring was altered. The revised range was then different for each individual HL configuration: four local and four global letters. The biggest range for pre-test HLs was 1348 milliseconds, with the smallest offering a range of 1051 milliseconds. For post-test the biggest range was 834 and the smallest 627. It is arguable that removing outliers created artificial ceiling effects. Ceiling effects are problematic as it may mask group differences due to low variances (Clark-Carter, 2012). Without removing the outliers the data was negatively skewed, which potentially creates a ceiling effect anyway. By removing outliers the training paradigm still provided a wide range of scores in order to detect group differences. It also enabled normal distribution assumptions to be fulfilled, and subsequently parametric analysis was undertaken.

During the process of removing outliers it became apparent that many were contained within the first five target stimuli. If the pre- and post-test paradigm was to be used in a future study, these observations would help inform revisions to the paradigm. It would be sensible to update the test of processing styles by

incorporating ‘dummy’ trials to further orientate people to the task. Although people completed eight practice trials, unlike the pre-test, these provided feedback on responses. The practice trials also appear to insufficiently orientate people to the task. Eyeballing the participants’ responses it is observable that once orientated to the task their response time became consistent. Thus, by building in ‘dummy’ trials, fewer outliers are likely to be detected and this increases the chance of maintaining a full data set.

With the global training repeatedly presenting stimuli at the global level, it is possible that costs to processing speed were incurred when having to switch between levels at post-test. Reaction times for typically developing people have been shown to be significantly longer switching from a global level to local, than in the opposite direction (Katagiri et al., 2013). Additionally, Katagiri et al. (2013) described costs in switching between levels after four repeated level trials have been shown to be greater than two repeated level trials. These results pertain to the current study, and may partway explain the difficulties those receiving the global training had at post-test, given we repeated one hundred and twenty eight repeated global trials. It suggests post training people had difficulty inhibiting processing hierarchical letters at the global level. Lamb, London, Pond and Whitt (1998) suggest difficulty in inhibiting a level of processing comes from activation of neural mechanism that are level specific and interferes with switching to another level: as our global training may have done.

4.4.6 Attentional Control Paradigm. The attentional control paradigm was designed to be neutral and thus neither bias attention towards local or global processing styles. The design consisted of one hundred and twenty eight trials of

randomly presented HLs stimuli, with an even number of local and global trials. In effect, this was an elongated version of the pre-test of four times the length and provided task experience for people. The attentional control provided a practice effect and allows the impact of additional practice to be compared against the global training paradigm. As indicated within the results section, attentional control had a bigger effect on both local and global processing than the global training. In hindsight, an alternative attentional control task, say completing an alternate task on the computer for the same amount of time, may have been more representative of an attentional control condition. Although, the attentional control used did highlight it is more beneficial to advise people with Asperger syndrome to undertake practice combining local and global, rather than global processing in isolation.

What reasons are behind the significant main effect of the attentional control condition for people with Asperger syndrome? Through imprinting, receptors developed for repeated stimuli could improve speed and accuracy of stimuli being detected. As noted for the global training (see Section 4.4.6), Lamb, London, Pond and Whitt's (1998) account of repeated trials activating specific receptors in the brain appears to be relevant to our findings. The attentional control condition would prevent specific inhibitors for levels of processing being activated, as pathways for both local and global processing are stimulated.

When explaining the results, it is also feasible to suggest people with Asperger syndrome benefited from task experience and the type of prolonged attention task rather than learning to switch attention per se. In an alternative prolonged attention task, involving correct rejection of items on an airport

security scanner, adults with autism improved their elimination of target-absence instances faster than people without the condition (Gonzalez et al., 2013). In essence, in simple visual search tasks, especially those looking at small details, people with Asperger syndrome may be better able to sustain the drive to do well (Gonzalez et al., 2013).

Caution should be used when interpreting the gains achieved in global processing by our Asperger syndrome groups, as typically an inter-level inference effect using Navon letters has impacted on the consistency of global trials more than that of local trials (Navon, 2003). This is relevant to our findings of the significant effect of group and condition for global processing, yet no significant differences evident for local processing. If global HL trials are more susceptible to inter-level inference, then the local processing results in our study could be taken as being more representative of processing differences between people with and without Asperger syndrome.

The notion that people with Asperger syndrome experience executive dysfunction was not supported by this study as they were able to switch attention between local and global stimuli. Interesting, as can be inferred by the current results, Katagiri et al. (2013) reported no significant differences in speed switching between local and global levels in either direction. This could explain why those people with Asperger syndrome benefited so positively from our attentional control condition and subsequent post-test. If interference between levels is similar for people with Asperger syndrome they appear primed to get faster at hierarchical letters randomly presented at both the local or global level.

4.4.7 Asperger syndrome rather than autism per se. The study recruited people with Asperger Syndrome rather than autism per se, the latter having more pronounced cognitive and language impairments (Scherf et al., 2008). Asperger syndrome shares many of the diagnostic features of autism, and individuals on the autism spectrum with unimpaired, good or even superior intellectual ability would have been eligible for the study (See Section 1.4.10 Summary of Findings). In the end, only people with Asperger syndrome were recruited. Our Asperger syndrome sample creates uniformity and permits easier comparisons between like studies but inhibits direct comparisons with low-functioning autistic spectrum disorder samples. The experimental computer paradigm has instructions to understand and follow in order to complete the task. It was felt people with a low functioning autistic spectrum disorder would have difficulty comprehending the instructions and completing the computer task.

In reviewing the group demographic it appears both the Asperger syndrome and typically developing groups were high-functioning samples. Given the heterogeneity of the Asperger population (Calero, Mata, Bonete, Molinero, & Gómez -Pérez, 2015) and our potentially atypical sample, there are limits to how generalisable the results are from this study to other Asperger populations. Another problem with a high-functioning sample is that ceiling effects may be created from the high baseline scores, which then leave limited room for improvement. Although all groups were closely matched to control for confounding variables, this process limits exploration of individual characteristics and any influence they have on the outcome measure used (Facon, Magis, & Belmont, 2011). Finally, high-functioning people with Asperger syndrome may have developed some compensatory strategies to help manage

any inherit processing deficits they have. If so, then the employment of compensatory strategies by high-functioning people with Asperger syndrome may mask between group differences.

4.5 Theoretical Implications of the Study Findings

Given the methodological limitations of the study, caution needs to be applied when exploring the theoretical and clinical implications of the study's findings.

4.5.1 *Local processing bias and reduced global processing in Asperger syndrome.*

The results from the present study do not appear to support the WCCT (Frith & Happé, 1994) hypothesis of a local processing bias in Asperger syndrome. Similarly, the findings challenge the hypothesis that the ability to integrate local elements into a coherent whole is impaired in Asperger syndrome. It has been suggested a local bias in novel tasks occurs because people with Asperger syndrome are simply better at segmenting complex information into smaller pieces (Jolliffe & Baron-Cohen, 1997). The study found no significant difference in, or significant changes to, local processing between people with Asperger syndrome and typically developing controls: following either global training or attentional control training. Behrmann et al. (2006) suggested that differences in local processing between people with and without Asperger syndrome do not arise at early stages of visual processing. Hence providing one explanation why the current study did not demonstrate a local processing bias for people with Asperger syndrome. Furthermore, this study used static stimuli and studies have debated local processing bias are more likely

to be observed in Asperger syndrome when testing motion perception (Gepner & Mestre, 2002).

The second part of the WCCT, proposing impaired information integration capabilities in Asperger syndrome, was not supported by this study's findings. Happé (1996) described that global impairments occur at the pre-attentive level and thus context would not be processed. To process global HLs participants need to integrate local features into a coherent whole. The fragmented HL stimuli could arguably draw attentional bias towards local features. Not so, as at baseline people with Asperger syndrome in this study were able to perform local and global processing in comparatively equal measures.

4.5.2 ***Enhancing global processing in Asperger syndrome.*** Happé and Frith (2006) proposed local processing bias as a dominant cognitive style in Asperger syndrome (See section 1.4.10), but that global processing could be performed when people are explicitly directed to do so. As noted in Section 4.3.1, the study's finding yielded little support for a local bias in Asperger syndrome. Nonetheless, global processing, and significant global improvements compared to typically developing peers, was observed. It should be noted this is not the first study to question the WCCTs account of a universal local processing bias for people with Asperger syndrome. Mottron, Burack, Stuader, and Robaey (1999) have reported adolescents with autism show a preference for global processing of hierarchical tasks when both global and local features are available to process. This finding was later replicated in adults by Rondan and Deruelle (2006).

Knowing that intact global processing for people with Asperger syndrome exists is congruent with recent research (Katsyri et al., 2008). Recently Katagiri et al. (2013) argued that global and local processing involve independent mechanisms, and in theory meant augmenting global processing in Asperger syndrome becomes viable. This study's findings also suggest global processing can be augmented for people with Asperger syndrome.

Another current finding to explore is why the attentional control condition caused significant gains in global processing speed. Inevitably, the paradigm measuring processing styles may have been influenced by the test being a divided attention task. Unlike Katagiri et al. (2008), the current study did not attempt to experimentally manipulate the repeated showing of trials at either the local or global level. The current pre- and post-test measure of processing style randomly presented hierarchical letters at either the local or global level. It is possible that even randomly generated hierarchical letters contained a sequence of letters repeatedly presented at the same perceptual level (local or global). If such a repeated sequence of same level trials occurred, then those people in the attentional control condition are likely to switch to a different level more quickly when compared to the training group. Katagiri et al. (2008) would attribute this advantage to being primed to switch between local and global level trials.

Other quite straightforward explanations exist as to why people with Asperger syndrome made more improvements with practice on our sustained attention task than like matched typically developing peers. Due to systemising tendencies (Baron-Cohen, 2006) people with Asperger syndrome may be interested in repetitive tasks and want to succeed at them. Conversely, people

without Asperger syndrome simply become bored more easily during the prolonged attention task (Gonzalez et al., 2013). Additionally, during alternative target rejection tasks people with Asperger syndrome have been suggested to be inherently better at visual search tasks, but just take longer that typically developing peers to reach peak levels of performance (Gonzalez et al., 2013).

4.5.3 Information processing theories for Asperger syndrome. The WCCT proposed people with Asperger syndrome display local processing bias as they are unable to integrate information into a coherent whole (Frith & Happé, 1994). The notion that people with Asperger syndrome get lost in the detail forever and are unable to process global information has not been upheld by this study. The results of improved local and global processing for people with Asperger syndrome would support the notion that each style of processing involves independent mechanisms (Happé & Booth, 2008). A 'normalcy of global analysis' effect in Asperger syndrome has been reported using HLs in a focused attention task overtly requiring local and global processing (Plaisted, et al., 1999). Further corroboration is provided by Caron et al. (2006), suggesting people with Asperger syndrome show greater interchangeability between local and global processing when tasks require it for a successful performance: necessary in identifying HLs quickly and accurately.

In accordance with the WCCT, the enhanced perceptual functioning hypothesis (EPF) suggests that low-level perceptual (local) processing is both superior and a default position in Asperger syndrome (Mottron, Dawson, Soulieres, Hubert, & Burack, 2006). The local processing might reflect an ability to detect small local differences at neurophysiological level and at the visual

level in visual search tasks. Moreover, and relevant to this study's findings, the EFP hypothesis proposes unimpaired global processing in Asperger syndrome. Preserved global processing is proposed to take a global-to-local order and has been found in autism populations: high functioning adolescents (Mottron, Burack, Stuader, & Robaey, 1999), high functioning children (Ozonoff et al., 1994) and children (Plaisted, et al., 1999). Certainly the current findings suggest intact visual-perceptual processing in people with Asperger syndrome, and is consistent with the EPF hypothesis (Mottron et al., 2006).

Evidence of intact local and global processing has implications for creating Asperger syndrome friendly environments. Additionally, while the EPF hypothesis (Mottron et al., 2006) indicates that global processing can be augmented in Asperger syndrome, little or no mention if given of whether gains are sustainable or need constant supporting. The reasons behind intact perceptual processes for people with Asperger syndrome need to be explored in more depth. Perceptual learning occurs when people are repeatedly exposed to specific stimuli, as both the global training and attentional control condition did in this study. A perceptual learning effect happens if changes to a perceptual system are changed and ultimately better equip people to respond to situations.

While it is beyond the scope of the current study to make claims about long lasting perceptual learning effects, a one minute break was enforced prior to post-test. In contrast to other research (Plaisted, O'Riordan & Baron-Cohen, 1998), it could be argued in the current study a perceptual learning effect was carried through to post-test when testing global processing with novel stimuli. Generally, perceptual learning effects are dependent on familiarity of the task

and being pre-exposed to the task, which happened between the attentional control condition and post-test. The task of identifying letters within hierarchical letters is also quite novel and may have neutralised people's pre-exposure to the task. It is also implicit that for perceptual learning effects to occur some extent of generalised learning has to occur, which is at odds to suggestions that people with Asperger syndrome are unable to generalise learning (Plaisted et al., 1998).

Another cognitive account of information processing in Asperger syndrome, the hyper-systemising theory (Baron-Cohen, 2006), argues that any bias towards local detail is to make sense of a system. As with the WCCT, excellent attention to detail and difficultly understanding gist is predicted in Asperger syndrome (O'Riordan, Plaisted, Driver & Baron-Cohen, 2001). The hyper-systemising theory differs in proposing that, in Asperger syndrome, understanding how a system works enables integration of information; which could explain global processing in Asperger syndrome for this study. The HL task performed within the study was repetitive in nature and required sustained attention from people undertaking the task to adhere to the rules of the system.

A dissociation between global and local processing in Asperger syndrome had been muted (Jolliffe & Baron-Cohen, 2001a), and this study's findings would support such a suggestion. A further distinction should be considered between global and configural processing, to see if deficits in one necessitate impairments in the other (Behrmann et al., 2006). Rondan and Deruelle (2007) reported that people with Asperger syndrome actually display a global preference for hierarchical tasks but a local preference in configural tasks. Greater clarity of whether global or configural processing is being tested within research might

help clarify some of the inconsistently reported finding of a presence or absence of global processing in Asperger syndrome.

4.5.4 *Enhancing global processing in typically developing people.*

Possibly the biggest surprise in the study's findings comes from the typically developing group receiving global training. In essence, the group demonstrated significantly less global processing improvements than like matched peers receiving attentional control, and people with Asperger syndrome in both the training and attentional control group. After a period of sustained global processing, the typically developing training group demonstrated a difficulty in switching attention back to a mixture of local and global processing. The finding is unexpected, and contradicts previous research outlining a difficulty switching between local and global processing is anticipated in Asperger syndrome (Katagiri et al., 2013; Rinehart, Bradshaw, Moss, Brereton, Tonge, 2001). Essentially, a local bias in Asperger syndrome was expected to inhibit switching attention to global aspects of HLs. Interestingly, Katagiri et al. (2013) reported typically developing individuals took significantly longer to switch from global to local HLs than in the other direction. Importantly, there was no significant difference in switching directions for the Asperger syndrome group. The results reported by Katagiri et al. support the current finding that training had significantly less gains in global processing for those typically developing people compared to all other groups tested. Interestingly, however, Katagiri et al. reported more costs for people with Asperger syndrome when switching from local to global processing. Thus, if we had employed a local rather than global training paradigm our results may have been somewhat different: suggesting

inhibiting enhanced local perceptual processing would impede global processing in Asperger syndrome.

4.6 Clinical Implications of the Study Findings

The theoretical revisions to the WCCT aid clinicians to conceptualise how adults with Asperger syndrome understand information. From the current findings, it seems important for clinicians to be aware that people with Asperger syndrome appear able to undertake global processing; albeit within the context of quickly identifying hierarchical letters. An improved understanding of the constructs of processing styles in Asperger syndrome could enable better recognition and diagnosis, and may lead to more people having their needs supported (Baron-Cohen, 2008).

Jolliffe and Baron-Cohen (1997) proposed people with Asperger syndrome can perform global processing when explicitly instructed to do so, which may explain the findings from the current study. Behrmann et al. (2006) latterly supported the position of intact global processing for people with Asperger syndrome, but that they processed more slowly when compared to typically developing peers. Though the findings of the current study suggests people with Asperger syndrome do not need additional time to process global information. The findings from this thesis indicate people with Asperger syndrome can process global information in a timely fashion, especially after receiving an attentional control computer condition. Although, as for Behrmann et al., it appears global processing by people with Asperger syndrome may be facilitated

by using local information. Thus, when local information is available it appears viable to include augmenting, in conjunction with supporting, processing styles in clinical practice for people with Asperger syndrome.

Even with the potential for global processing, it is suggested that for people with Asperger syndrome vital contextual information remains unprocessed and inhibits learning being generalised to different contexts (Plaisted et al., 1998). An example of difficulties people with Asperger syndrome have in generalising learning is provided by improvements in emotion perception on computerised tasks not transferring to more natural situations (Golan & Baron-Cohen, 2006). Unfortunately, it is not feasible to say if the global processing gains for people with Asperger syndrome, documented in this thesis, can be generalised to other contexts.

The WCCT has not typically offered insight into difficulties people with Asperger syndrome experience using language in social communication (Jarrold et al., 2000). To do so, could be regarded as an over extension for the WCCT theory. Difficulties people with Asperger syndrome have interpreting language within context could be explained by the fixation on individual details of communication, literal interpretations and displays of contextually inappropriate behaviour (Jolliffe & Baron-Cohen, 2000). Although augmenting global processing for people with Asperger syndrome was achieved within this study, it is not viable to suggest it would improve language interpretation within context.

4.7 Future Research Directions

Beyond clarifying local bias in Asperger syndrome, a number of directions for future research seem viable. Crucially, the flexibility of processing styles for people with Asperger syndrome requires further exploration. As shown by this study, processing styles can be modified for people with Asperger syndrome. As such, future experimental training paradigms could be adapted to contain a process of switching between local and global stimuli, as our attentional control condition did. It could become feasible to create versions of experimental paradigms tailored to individual needs and available for people to use daily (Tanaka et al., 2010). Research could be conducted on personal computers, permitting daily training to be completed and to review if gains in perceptual learning are maintained. Any subsequent changes in processing style could be tracked to see how they translated to functioning in everyday life for individuals with Asperger syndrome. One method of tracking processing styles changes could be through 3-D virtual reality simulators using specially designed environments with target stimuli to provide a measure of processing. Additionally, observed behaviour could be incorporated within research to further our understanding of the relationship between processing styles and everyday atypical behaviour by individuals with Asperger syndrome (Geurts et al., 2009).

Age may affect the presence and development of global processing abilities in people with Asperger syndrome (Deruelle, Rondan, Gepner, & Tardif, 2004). Deruelle et al. (2004) suggest that global processing performance increases throughout childhood and also into adulthood (Rondan & Deruelle,

2004). By focusing on adults, and studies with a cross-sectional design, the proposed shift during adolescence from local to global processing was excluded from exploration by this study (Scherf et al., 2008). If future research adopted a longitudinal design the proposed developmental trajectory could be explored for people with Asperger syndrome (Katagiri et al., 2013).

If people with Asperger syndrome do benefit from practice at repetitive and prolonged attention tasks, then between and within group differences could be investigated. Future studies could explore the motivational and cognitive factors that may influence sustained task performance (Gonzalez, Best, Healy, Bourne, & Kole, 2010). If we can understand the processes that enable people with Asperger syndrome to engage with sustained attention tasks then these findings could be applied to many real-world monitoring tasks (Gonzalez et al., 2013). The value of correct identification of stimuli, or even correct rejection as in Gonzalez et al. (2013), in everyday visual search situations is important. Particularly, given typically developing adults reportedly have difficulties at long vigilance and whose performance often deteriorates in sustained attention tasks (Ballard, 1996).

Another area for future research should be to investigate whether an even or uneven processing profile exists across the continuum of autism spectrum presentations (Vanegas & Davidson, 2015). It has been suggested that children with Asperger syndrome demonstrate similar processing tendencies on both visuospatial tasks and linguistic tasks, whereas children with high-functioning autism only show a greater reliance on local information in linguistic tasks (Loth, Gómez, & Happé, 2008). Research into the cognitive profile of adults with

differing autism presentations remains relatively unexplored, particularly across varied processing modalities. If the heterogeneous nature of the Asperger population can be understood, any individual differences unearthed better informs assessment, intervention and prognosis for the condition (Calero et al., 2015). Finally, any future research testing processing style in any autism population, needs to ensure any measures used adequately tap into the qualitative processing differences that may or may not exist within autism populations or between people with and without the condition.

4.8 Conclusions

The current study aimed to investigate a local processing bias in adults with Asperger syndrome (Frith and Happé, 1994). Secondly, an experimental computerised training paradigm was used to try to significantly improve the ability of people with Asperger syndrome to process information pertaining to global processing. In summary, individuals with Asperger syndrome did not present with any significant differences in either local or global processing style, when compared to like matched typically developing adults. The findings would not support the WCCTs (Frith & Happé, 1994) account of a local processing bias existing for people with Asperger syndrome. Furthermore, no significant differences in global processing style were detected between people with or without Asperger syndrome. Typically developing individuals were able to process information in its wider context (Hill & Frith, 2003), but so could people with Asperger syndrome. In essence people with and without Asperger syndrome could look at the ‘‘bigger picture’’. However, it is feasible that these results are

due to superior emotional inhibition and sustained attention abilities people with Asperger syndrome are proposed to possess (Gonzalez et al., 2010).

Our experimental computerised training paradigm did not significantly improve the ability of people with Asperger syndrome to process information pertaining to global processing, after receiving global training, but the attentional control condition did. The direction of this significant result was unexpected and the reverse to predicted. To make sense of HLs people with Asperger syndrome did not do so at the expense of integrating pieces of information into a coherent whole. Thus, these findings support the WCCT's revised hypothesis that people with Asperger syndrome can process globally when explicitly instructed to do so (Happé & Frith, 2006). The WCCT's account of fewer gains expected in global processing for people with Asperger syndrome is unsupported by the current findings. Refinements to the WCCT (Happé & Booth, 2008) emphasising a reduced ability to integrate information to form a whole are not supported by findings from people with Asperger syndrome in this study.

With the gains in global processing for those people with Asperger syndrome achieved via the attentional control condition, it suggests attempts to augment global processing should expose people to a mixture of local and global stimuli. A newly designed experimental training that focusses on both local and global processing, as our attentional control did, may be ecologically valid and also support any costs in switching from local and global processing for people with Asperger syndrome. Although, it is noteworthy that any further research exploring processing styles should carefully consider the emotional inhibition abilities of people with Asperger syndrome and the influence the construct may

have on the results. Any further understanding into the characteristics of processing by people with Asperger syndrome may contribute to clinical interventions being developed (Katagiri et al., 2013), potentially those of the experimental computerised variety.

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6 Appendices

6.1 List of Appendices

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Appendix A: Demographic details:

Demographic Information	Details
Age of person	
Gender	
Education Level Achieved	
Handedness	
IQ	
Age at diagnosis – AS	
Family History of ASD	
Mental Health Needs (Neuropsychiatric disorder)	
Physical Health Needs	
Medication usage	
History of brain injury	

Appendix B: The Autistic-Spectrum Quotient (AQ) 10-item

Attention to detail (original item number from AQ-50)

1. I often notice small sounds when others do not. (5)

definitely agree slightly agree slightly disagree definitely disagree

2. I usually concentrate more on the whole picture, rather than the small details. (28)

definitely agree slightly agree slightly disagree definitely disagree

Attention switching

3. I find it easy to do more than one thing at once. (32)

definitely agree slightly agree slightly disagree definitely disagree

4. If there is an interruption, I can switch back to what I was doing very quickly. (37)

definitely agree slightly agree slightly disagree definitely disagree

Communication

5. I find it easy to "read between the lines" when someone is talking to me. (27)

definitely agree slightly agree slightly disagree definitely disagree

6. I know how to tell if someone listening to me definitely is getting bored. (31)

definitely agree slightly agree slightly disagree definitely disagree

Imagination

7. When I'm reading a story, I find it difficult to work out the characters' intentions. (20)

definitely agree slightly agree slightly disagree definitely disagree

8. I like to collect information about categories of things (e.g. types of car, types of bird, types of train, types of plant, etc.). (41)

definitely agree slightly agree slightly disagree definitely disagree

Social

9. I find it easy to work out what someone is thinking or feeling just by looking at their face. (36)

definitely agree slightly agree slightly disagree definitely disagree

10. I find it difficult to work out people's intentions. (45)

definitely agree slightly agree slightly disagree definitely disagree

Appendix C: Participant Information Sheet – for people with Asperger Syndrome

Information sheet for Research – People with Asperger Syndrome

CAN TRAINING PARADIGMS ENHANCE GLOBAL PROCESSING STYLE IN PEOPLE WITH ASPERGER SYNDROME: A RANDOMISED EXPERIMENT

My name is Graham Beales and I am a Trainee Clinical Psychologist based at the University of East Anglia (UEA). My research supervisors are Dr. Peter Langdon, Clinical Senior Lecturer and Dr. Lynne Roper, Clinical Lecturer, on the Doctoral Programme in Clinical Psychology at the UEA. I am writing to invite you to take part in a research project. This information sheet is to help you decide if you are happy to participate. Please take time to read it carefully. Please feel free to contact me if you require any further information.

What is the purpose of the project?

This project aims to explore processing styles (the way people understand information) in individuals with and without Asperger Syndrome. It is hoped that a computerised training programme can enhance processing styles, and improve the ability of individuals with Asperger Syndrome to use contextual information. Some processing styles can affect people's ability to interpret others emotions, communications and behaviour. This can then impact on social functioning, ability to cope in a work environment and general mental health. Therefore, this study aims to examine processing styles in adults with and without Asperger Syndrome and whether a computerised training programme can enhance processing styles. From a practical standpoint, computer-based training could become accessible at individuals homes or GP surgeries and used on multiple media formats. A successful training programme can be customised to the individuals needs and used at times most convenient around individuals life demands.

In order to investigate this, I am asking people who have been diagnosed with Asperger Syndrome and people without Asperger Syndrome, to complete a computerised training programme. It is hoped that the results of the project will help develop further computerised training to support thinking styles for people with Asperger Syndrome. Thus far, very little research has been completed to look at this type of support.

Why have I been invited to participate?

You have been asked to participate because you are an adult, with Asperger Syndrome. You have been provided with this Participant Information Sheet and will need to decide whether to complete the Consent to Share Details. The signed Consent to Share Details form, once sent to me, allows me to contact you to explain the study further. You have been asked to participate because you have stated that it is ok for me to contact you regarding my research. To participate further you will need to be able to understand and sign the written consent form to provide informed consent.

What will happen if I decide to give consent to take part?

If you decide that you are happy to take part in the project, I will meet with you for approximately 20 minutes, either at home, or if you prefer somewhere else. This would be to complete screening questionnaires and an assessment to ensure you are eligible to take part in the study. If you would prefer, it is also possible for me to complete the questionnaires over the phone but the screening assessment would need to be completed in person. I will also ask you if you can confirm that you have a diagnosis of Asperger Syndrome and roughly how old you were when you received the diagnosis.

After the screening process has been completed, some people may be ineligible to take part in the study. Unfortunately, if this happens you will not be able to complete the training. If this happens it may be disappointing for you, but you will be provided with reasons why you are unable to take part in the training. A possible reason could be that you might have difficulty understanding the tasks. If this happens it may be advisable for you to see your GP for support with understanding information. You will also be provided with the option of having all information about you, collected during the screening process, destroyed confidentially.

If you are eligible to take part, after initial screening demonstrates you meet the inclusion criterion, the computerised tasks start. The computer task will be

completed individually. Half of the people taking part will then complete one type of computerised training, while the other half complete a different type of computerised training, to see if the different training helps improve thinking styles. To see if the training has made any difference, a computerised task will be completed before and after the training. Your scores from before and after the training will be compared to see if the training has made any difference to your thinking style. These tasks involve identifying letters as fast and accurately as you can when presented on the computer screen. In total, the computerised tasks and training should take about 30 minutes to complete.

What if I change my mind and want to stop being involved?

You are free to change your mind about being involved in the study. It is important you understand that your participation is voluntary. You are free to withdraw your involvement at any time, without giving any reason and without any services you receive being affected. If you are an NHS patient or receive services from Asperger East Anglia it is important that you know withdrawal from the study will not have any effect on care you receive as a patient.

What will happen if I become distressed?

In the unlikely event that you become distressed in any way whilst participating, I will stop the study immediately. In this situation, I would also inform my primary research supervisor about the situation; however no personal details will be shared.

What do I have to do if I would like to take part?

If you are interested in taking part in this project, you will need to provide written consent. Please fill out the consent to share details form enclosed and return it to the UEA address at the bottom of the information sheet. I will then contact you to discuss the study and answer any questions and concerns you may have. If you are happy to participate after this I will arrange to come and visit you to complete the screening questionnaires. If you would prefer, I can arrange to complete the questionnaires over the phone but the screening assessment will need to be completed in person.

Are there any expenses to me to be involved in the study?

Ideally the study will take place in a quiet and distraction free room at Asperger East Anglia offices. However, the budget attached to the study does not enable

any travel costs incurred to be reimbursed. The alternative would be for me to travel to you if you decide to become involved in the study. It is important that if I travel to you we would need a room without any distractions. Once the training starts it would not be able to be restarted. Unfortunately, if interruptions occur your participation would not be counted. To make arrangements I will call you to cover the costs of the telephone call. Also, all correspondence that needs to be returned to me will be sent with a stamped addressed envelope.

What are the disadvantages and risks of my taking part?

It is not envisaged that there are any risks to you in taking part. However, we acknowledge that you are giving up time to part take in the study. You will be informed that you can stop the tasks at any time, should you wish to or to take a break.

What are the possible benefits of taking part?

It is hoped that the computerised training programme being used could be developed to support enhancing processing styles for individuals with or without Asperger Syndrome. By taking part in the study, each participant will be entered into a prize draw with the potential to win a £30 Amazon voucher.

Will information be kept confidentially?

All information will be private and safe, apart from if you disclose information which causes concern for your safety or the safety of others. I am obliged to keep you and others safe, and would need to pass on this information to ensure this happens. All questionnaires and assessments will be kept in a locked cabinet, and files and tasks on computers will be password protected. No identifying information (such as names) will be included in the reporting but you will not be anonymous to me as I would be seeing you in person. All participants will be provided with a unique identifying number for their data, which can be found on the tear off slip. The randomly assigned unique identifying number is not known by the researcher but enables you to identify your data if you wish to withdraw from the study and have your data destroyed. All assessments will be securely destroyed once analysis has taken place or if you withdraw from the study.

Who has reviewed the study?

All research in the NHS and at the University of East Anglia is looked at by an independent group of people called a Research Ethics Committee, to protect your

interests. This study has been reviewed and given a favourable opinion by the Hatfield Research Ethics Committee.

Thank you for taking the time to read this information sheet. I hope you will decide to participate. Should you have any questions I would be very happy to discuss my project further with you and can be contacted Tel: 07851 319347 (please leave a message and I will get back to you) or email me @ G.Beales@uea.ac.uk. If wish to speak to one of my supervisors then they are contactable on 01603 711178 or Email: P.Langdon@uea.ac.uk

If you would like to speak to someone independent about taking part in research, then you could contact INVOLVE: By **Telephone**: 023 8065 1088, **Textphone**: 023 8062 6239, **Email**: admin@invo.org.uk or go to www.invo.org.uk.

If you feel unhappy about the way you have been treated or wish to make a complaint speak to the researcher (on 07851 319347 or Email: G.Beales@uea.ac.uk) who will do their best to resolve any problems. If you remain unsatisfied or would like to complain formally you can contact the Patient Advice and Liaison Service (PALS) (on 01603 421191) for further advice and information. **Alternatively, complaints can be made directly to** Professor Ken Laidlaw (Doctoral Programme in Clinical Psychology Course Director at the UEA) on 01603 593076 or Email: K.Laidlaw@uea.ac.uk

THANKS

FOR READING ABOUT THIS STUDY

Appendix D: Participant Information Sheet for people without Asperger Syndrome

Information sheet for Research – People without Asperger Syndrome

CAN TRAINING PARADIGMS ENHANCE GLOBAL PROCESSING STYLE IN PEOPLE WITH ASPERGER SYNDROME: A RANDOMISED EXPERIMENT

My name is Graham Beales and I am a Trainee Clinical Psychologist based at the University of East Anglia (UEA). My research supervisors are Dr. Peter Langdon, Clinical Senior Lecturer and Dr. Lynne Roper, Clinical Lecturer, on the Doctoral Programme in Clinical Psychology at the UEA. I am writing to invite you to take part in a research project. This information sheet is to help you decide if you are happy to participate. Please take time to read it carefully. Please feel free to contact me if you require any further information.

What is the purpose of the project?

This project aims to explore processing styles (the way people understand information) in individuals with and without Asperger Syndrome. It is hoped that a computerised training programme can enhance processing styles, and improve the ability of individuals with Asperger Syndrome to use contextual information. Some processing styles can affect people's ability to interpret others emotions, communications and behaviour. This can then impact on social functioning, ability to cope in a work environment and general mental health. Therefore, this study aims to examine processing styles in adults with and without Asperger Syndrome and whether a computerised training programme can enhance processing styles. From a practical standpoint, computer-based training could become accessible at individuals homes or GP surgeries and used on multiple media formats. A successful training programme can be customised to the individuals needs and used at times most convenient around individuals life demands.

In order to investigate this, I am asking people who have been diagnosed with Asperger Syndrome and people without Asperger Syndrome, to complete a computerised training programme. It is hoped that the results of the project will help develop further computerised training to support thinking styles for people with Asperger Syndrome. Thus far, very little research has been completed to look at this type of support.

Why have I been invited to participate?

You have been asked to participate because you are an adult, without Asperger Syndrome. You have been provided with this Participant Information Sheet and will need to decide whether to complete the Consent to Share Details. The signed Consent to Share Details form, once sent to me, allows me to contact you to explain the study further. You have been asked to participate because you have stated that it is ok for me to contact you regarding my research. To participate further you will need to be able to understand and sign the written consent form to provide informed consent.

What will happen if I decide to give consent to take part?

If you decide that you are happy to take part in the project, I will meet with you for approximately 20 minutes, either at home, or if you prefer somewhere else. This would be to complete screening questionnaires and an assessment to ensure you are eligible to take part in the study. If you would prefer, it is also possible for me to complete the questionnaires over the phone but the screening assessment would need to be completed in person.

After the screening process has been completed, some people may be ineligible to take part in the study. Unfortunately, if this happens you will not be able to complete the training. If this happens it may be disappointing for you, but you will be provided with reasons why you are unable to take part in the training. A possible reason could be that you might have difficulty understanding the tasks or you might have some autistic-like qualities. This would not mean you have autism but if this happens it may be advisable for you to see your GP for support with understanding information. You will also be provided with the option of having all information about you, collected during the screening process, destroyed confidentially.

If you are eligible to take part, after initial screening demonstrates you meet the inclusion criterion, the computerised tasks start. The computer task will be completed individually. Half of the people taking part will then complete one

type of computerised training, while the other half complete a different type of computerised training, to see if the different training helps improve thinking styles. To see if the training has made any difference, a computerised task will be completed before and after the training. Your scores from before and after the training will be compared to see if the training has made any difference to your thinking style. These tasks involve identifying letters as fast and accurately as you can when presented on the computer screen. In total, the computerised tasks and training should take about 30 minutes to complete.

What if I change my mind and want to stop being involved?

You are free to change your mind about being involved in the study. It is important you understand that your participation is voluntary. You are free to withdraw your involvement at any time, without giving any reason and without any services you receive being affected. If you are an NHS patient it is important that you know withdrawal from the study will not have any effect on care you receive as a patient.

What will happen if I become distressed?

In the unlikely event that you become distressed in any way whilst participating, I will stop the study immediately. In this situation, I would also inform my primary research supervisor about the situation; however no personal details will be shared.

What do I have to do if I would like to take part?

If you are interested in taking part in this project, you will need to provide written consent. Please fill out the consent to share details form enclosed and return it to the UEA address at the bottom of the information sheet. I will then contact you to discuss the study and answer any questions and concerns you may have. If you are happy to participate after this I will arrange to come and visit you to complete the screening questionnaires. If you would prefer, I can arrange to complete the questionnaires over the phone but the screening assessment will need to be completed in person.

Are there any expenses to me to be involved in the study?

Ideally the study will take place in a quiet and distraction free room at Asperger East Anglia offices. However, the budget attached to the study does not enable

any travel costs incurred to be reimbursed. The alternative would be for me to travel to you if you decide to become involved in the study. It is important that if I travel to you we would need a room without any distractions. Once the training starts it would not be able to be restarted. Unfortunately, if interruptions occur your participation would not be counted. To make arrangements I will call you to cover the costs of the telephone call. Also, all correspondence that needs to be returned to me will be sent with a stamped addressed envelope.

What are the disadvantages and risks of my taking part?

It is not envisaged that there are any risks to you in taking part. However, we acknowledge that you are giving up time to part take in the study. You will be informed that you can stop the tasks at any time, should you wish to or to take a break.

What are the possible benefits of taking part?

It is hoped that the computerised training programme being used could be developed to support enhancing processing styles for individuals with or without Asperger Syndrome. By taking part in the study, each participant will be entered into a prize draw with the potential to win a £30 Amazon voucher.

Will information be kept confidentially?

All information will be private and safe, apart from if you disclose information which causes concern for your safety or the safety of others. I am obliged to keep you and others safe, and would need to pass on this information to ensure this happens. All questionnaires and assessments will be kept in a locked cabinet, and files and tasks on computers will be password protected. No identifying information (such as names) will be included in the reporting but you will not be anonymous to me as I would be seeing you in person. All participants will be provided with a unique identifying number for their data, which can be found on the tear off slip. The randomly assigned unique identifying number is not known by the researcher but enables you to identify your data if you wish to withdraw from the study and have your data destroyed. All assessments will be securely destroyed once analysis has taken place or if you withdraw from the study.

Who has reviewed the study?

All research in the NHS and at the University of East Anglia is looked at by an independent group of people called a Research Ethics Committee, to protect your

interests. This study has been reviewed and given a favourable opinion by the Hatfield Research Ethics Committee.

Thank you for taking the time to read this information sheet. I hope you will decide to participate. Should you have any questions I would be very happy to discuss my project further with you and can be contacted Tel: 07## ####### (please leave a message and I will get back to you) or email me @ G.Beales@uea.ac.uk. If wish to speak to one of my supervisors then they are contactable on 01603 711178 or Email: P.Langdon@uea.ac.uk

If you would like to speak to someone independent about taking part in research, then you could contact INVOLVE: By **Telephone**: 023 8065 1088, **Textphone**: 023 8062 6239, **Email**: admin@invo.org.uk or go to www.invo.org.uk.

If you feel unhappy about the way you have been treated or wish to make a complaint speak to the researcher (on 07851 319347 or Email: G.Beales@uea.ac.uk) who will do their best to resolve any problems. If you remain unsatisfied or would like to complain formally you can contact the Patient Advice and Liaison Service (PALS) (on 01603 421191) for further advice and information. **Alternatively, complaints can be made directly to** Professor Ken Laidlaw (Doctoral Programme in Clinical Psychology Course Director at the UEA) on 01603 593076 or Email: K.Laidlaw@uea.ac.uk

THANKS

FOR READING ABOUT THIS STUDY

Appendix E: Consent to Share Details

University of East Anglia

Consent to Share Details

Can training paradigms enhance global processing style in people with Asperger Syndrome? A randomised experiment

Please initial the boxes

1. I.....(name) I have been given a participant information sheet dated..... about the above study ☐

2. I give consent for Graham Beales, Trainee Clinical Psychologist at the University of East Anglia to contact me about this study. I understand that he will contact me discuss involvement and answer any questions I may have. ☐

3. I understand that by giving my consent to be contacted I am not under any obligation to participate in the study. ☐

Name:..... **Signature:**.....
Date:.....

Address:.....
.....
.....
.....

Telephone number.....

Email Address.....

Preferred time to be contacted.....

Thank you for your help.

Graham Beales, Trainee Clinical Psychologist.
Email: G.Beales@uea.ac.uk Phone: 07xxxxxxx

Appendix F: Participant Consent Form

University of East Anglia

Consent form

Can training paradigms enhance global processing style in people with Asperger Syndrome? A randomised experiment

Please initial the boxes

1. I confirm that I have read the information sheet dated..... for the above study. ☐

2. I have the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

3. I understand that my participation is voluntary and I am free to withdraw involvement at any time, without giving any reason and without any services I receive being affected. ☐

4. I understand that all data collected will remain confidential, and that this will be stored securely and destroyed at the end of the study. ☐

5. I understand that after the screening process I might not be eligible to take part in the study. ☐

6. I agree that I am happy to take part in the screening process and above study if eligible. ☐

Would you like to receive a written summary of the findings on completion of the research? Please delete as applicable - YES/NO

_____	_____	_____
Name of Person	Date	Signature
_____	_____	_____
Name of person taking consent	Date	Signature

Thank you for your help.

Graham Beales, Trainee Clinical Psychologist. Email: G.Beales@uea.ac.uk Phone: 07xxxxxxxx

Appendix G: Recruitment Poster

Can training paradigms enhance global processing style in people with Asperger Syndrome? A randomised experiment

Researcher: Graham Beales

Research Supervisor: Dr Peter Langdon and Dr Lynne Roper

Purpose

This project aims to explore processing styles (the way people understand information) in individuals with and without Asperger Syndrome. It is hoped that a computerised training programme can enhance processing styles, and improve ability to use contextual information for individuals with Asperger Syndrome. Some processing styles can affect people's ability to interpret others; emotions, communications and behaviour. This can then impact on social functioning, ability to cope in a work environment and general mental health. Therefore, this study aims to examine processing styles in adults with and without Asperger Syndrome and whether a computerised training programme can enhance processing styles.

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Inclusion Criteria:

- People with a diagnosis of Asperger Syndrome and aged 18-65 years old
- People without a diagnosis of Autistic Spectrum Disorder and aged 18-65 years old.

Exclusion Criteria:

- People with a diagnosis of Autistic Spectrum Disorder
- People who do not speak or understand English
- People with a developmental or neurological disorder which makes them unable to communicate or understand

If you require any further information about this study,

please contact me at G.Beales@uea.ac.uk or on 07xxxxxxxxx

By taking part in the study, each participant will be entered into a prize draw with the potential to win a £30 Amazon voucher.

Thank you for taking the time to read this!

Appendix H: Navon stimuli

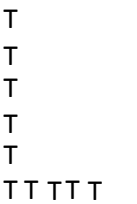
The Navon Figures Test

The Navon figures (Navon, 1977) are figures which have both local and global elements. In the case of the first example below you see a letter "H" (global level) made up of smaller letter "F"s (local level). To test global/local processing style, participants are presented with each figure on a computer screen and are then asked to respond as quickly as possible as to whether it contains one of two target letters (e.g., "F" or "L") by pressing the appropriate key. Sometimes the target letters are represented at the local level (small letters, example 1) and sometimes at the global level (large letters, example 2). A number of trials are presented in succession. If participants are faster to respond when the target letter is represented at the global level then you could assume that they are displaying a more global cognitive style. If they are faster when the target letter is presented at the local level then you would assume that they are displaying a more local cognitive style. This task has been used successfully in this way to assess global and local processing by Forster & Higgins (2005).

Example 1:

Is the letter "F" or "L" present?

Example 2:

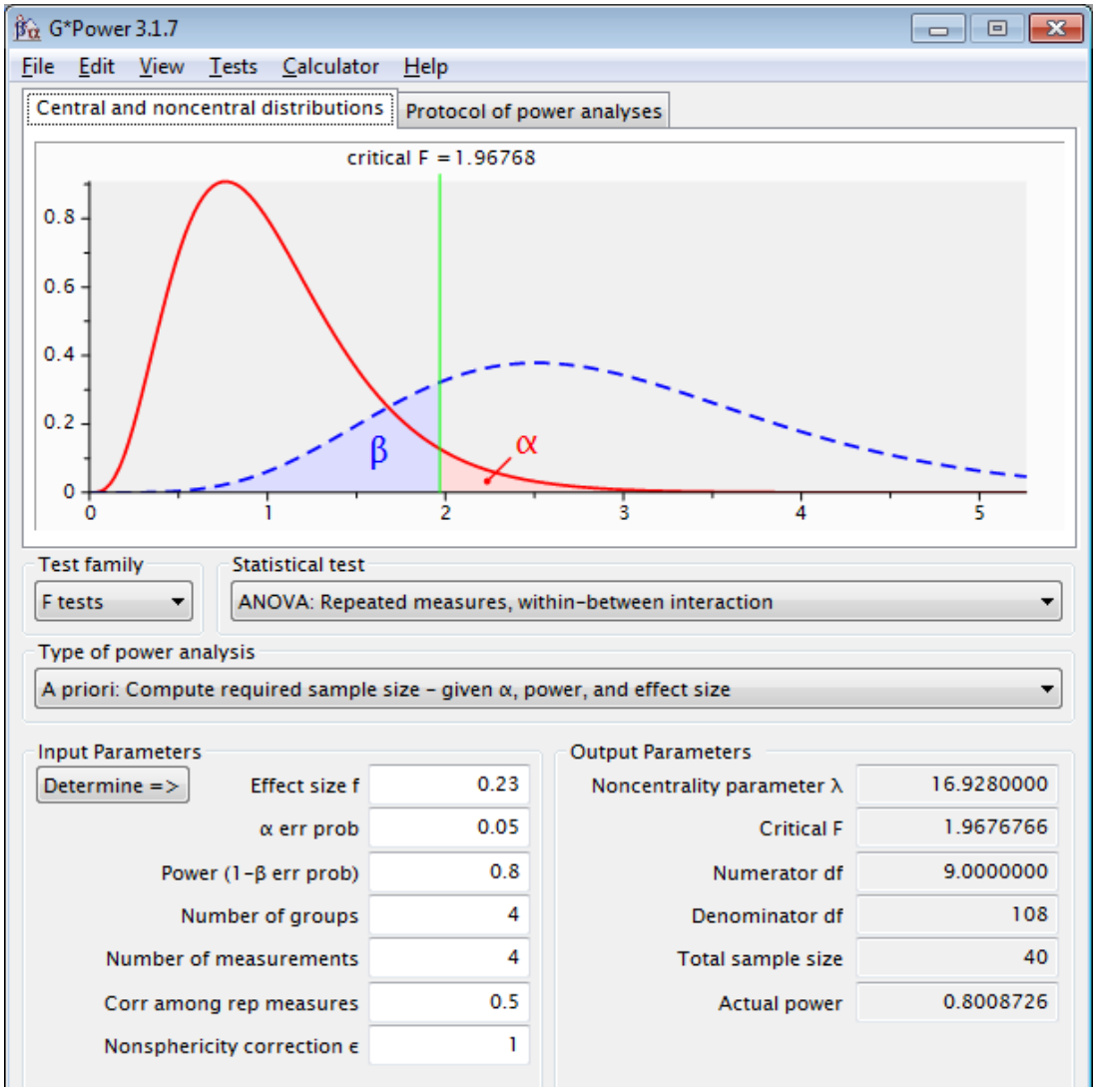


Is the letter "F" or "L" present?

Appendix I: G Power calculations

Primary Hypothesis

Looking at change across the repeated measures factor (time) only, the calculated sample size is as follows (n = 10 per group):



Appendix J: ICD-10 diagnostic criteria for Autism

Diagnostic criteria for F84.0 childhood autism

A. Abnormal or impaired development is evident before the age of three years of age in at least one of the following areas:
    1. receptive language or expressive language used in social communication;
    2. the development of selective social attachments or of reciprocal social interaction;
    3. functional or symbolic play.
B. At least six symptoms from 1, 2 and 3 must be present, with at least two from 1 and at least one from each of 2 and 3:
    1. Qualitative abnormalities in reciprocal social interaction are manifest in at least two of the following areas:
        a) failure adequately to use eye-to-eye gaze, facial expression, body posture and gesture to regulate social interaction:
        b) failure to develop (in a manner appropriate to mental age despite ample opportunities) peer relationships that involve a mutual sharing of interests, activities and emotions;
        c) lack of socioemotional reciprocity as shown by an impaired or deviant response to other people's emotions; or lack of modulation of behaviour according to social

context: or weak integration of social, emotional and communicative behaviours;

d) lack of spontaneous seeking to share enjoyment, interests or achievements with other people (e.g. a lack of showing, brining or pointing out to other people objects of interest to the individual).

2. Qualitative abnormalities in reciprocal social interaction are manifest in at least two of the following areas:

a) a delay in, or total lack of, development of spoken language that in not accompanied by an attempt to compensate through use of gesture or mine as an alternative mode of communication (often preceded by a lack of communicative babbling);

b) relative failure to initiate or sustain conversational interchange (at whatever level of language skills is present), in which there is reciprocal responsiveness to the communication of the other person;

c) stereotyped and repetitive use of language or idiosyncratic use of words or phrases;

d) lack of varied spontaneous make-believe or (when young) social imitative play.

3. Qualitative abnormalities in reciprocal social interaction are manifest in at least two of the following areas:

a) an encompassing preoccupation with one or more stereotyped and restricted patterns of interest that are

abnormal in content or focus; or one or more interests that are abnormal in their intensity and circumscribed nature though not in their content or focus;

b) apparently compulsive adherence to specific, non-functional routines or rituals;

c) stereotyped and repetitive motor mannerisms that involve either hand or finger flapping or twisting, or complex whole body movements;

d) preoccupations with part-objects or non-functional elements of play materials (such as their odour, the feel of their surface, or the noise or the vibration that they generate).

C. The clinical picture is not attributable to other varieties of pervasive developmental disorder: specific developmental disorder to receptive language (F80.2) with secondary socioemotional problems; (F20.6); reactive attachment disorder (F94.1) or disinhibited attachment disorder (F94.2): mental retardation (F70-F72) with some associated emotional or behavioural disorder: schizophrenia (F20-) of unusually early onset: and Rett's syndrome (F84.2).

World Health Organisation (1993) Mental Disorders: A glossary and guide to their classification in accordance with the 10th revision of the International Classification of Diseases (ICD-10). Geneva: World Health Organisation.

Appendix K: ICD-10 diagnostic criteria for Asperger syndrome

Diagnostic criteria for F84.5 Asperger syndrome

D. There is generally not significant general delay in spoken or receptive language or cognitive development. Diagnosis requires that single words should developed by two years of age or earlier and that communicative phrases be used by three years of age or earlier. Self-help skills, adaptive behaviour and curiosity about the environment during the first three years should be at a level consistent with normal intellectual development. However, motor milestones may be somewhat delayed and motor clumsiness is usual (although not a necessary diagnostic feature). Isolated special skills, often related to abnormal preoccupations, are common, but are not required for diagnosis.

E. There are qualitative abnormalities in reciprocal social interaction (criteria as for autism).

F. The individual exhibits an unusually intense, circumscribed interest or restricted, repetitive and stereotyped patterns of behaviour, interests and activities (criteria as for autism: however, it would be less usual for these to include motor mannerisms or preoccupations with part-objects or non-functional elements of play materials).

G. The disorder is not attributable to other varieties of pervasive developmental disorder: simple schizophrenia (F20.6); schizotypal disorder (F21): obsessive-compulsive disorder (F42.-); anankastic personality disorder (F60.5); reactive and disinhibited attachment disorders of childhood (F94.1 and F94.2 respectively).

World Health Organisation (1993) Mental Disorders: A glossary and guide to their classification in accordance with the 10th revision of the International Classification of Diseases (ICD-10). Geneva: World Health Organisation.

Appendix L: Letter from the Research Ethics Committee East of England – Hatfield

NHS
Health Research Authority

NRES Committee East of England - Hatfield
Rolling Mill Road
Jarrow
Tyne and Wear
NE32 3DT

Telephone: 0191 4283564

26 August 2014

Mr Graham Beales
University of East Anglia
Faculty of Medicine and Health Sciences
Doctoral Programme in Clinical Psychology
Norwich
NR4 7TJ

Dear Mr Beales

Study title:	**Can training paradigms enhance global processing style in people with Asperger Syndrome? A randomised experiment**
REC reference:	**14/EE/0217**
Protocol number:	**N/A**
IRAS project ID:	**149582**

Thank you for your recent correspondence, responding to the Committee's request for further information on the above research and submitting revised documentation.

The further information was considered in correspondence by a Sub-Committee of the REC. A list of the Sub-Committee members is attached.

We plan to publish your research summary wording for the above study on the HRA website, together with your contact details. Publication will be no earlier than three months from the date of this opinion letter. Should you wish to provide a substitute contact point, require further information, or wish to make a request to postpone publication, please contact the REC Manager, Miss Kathryn Murray, nrescommittee.eastofengland-hatfield@nhs.net.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Appendix L: Letter from the Research Ethics Committee East of England – Hatfield

Conditions of the favourable opinion

The favourable opinion is subject to the following conditions being met prior to the start of the study.

Management permission or approval must be obtained from each host organisation prior to the start of the study at the site concerned.

Management permission ("R&D approval") should be sought from all NHS organisations involved in the study in accordance with NHS research governance arrangements.

Guidance on applying for NHS permission for research is available in the Integrated Research Application System or at http://www.rdforum.nhs.uk.

Where a NHS organisation's role in the study is limited to identifying and referring potential participants to research sites ("participant identification centre"), guidance should be sought from the R&D office on the information it requires to give permission for this activity.

For non-NHS sites, site management permission should be obtained in accordance with the procedures of the relevant host organisation.

Sponsors are not required to notify the Committee of approvals from host organisations

Registration of Clinical Trials

All clinical trials (defined as the first four categories on the IRAS filter page) must be registered on a publicly accessible database within 6 weeks of recruitment of the first participant (for medical device studies, within the timeline determined by the current registration and publication trees).

There is no requirement to separately notify the REC but you should do so at the earliest opportunity e.g when submitting an amendment. We will audit the registration details as part of the annual progress reporting process.

To ensure transparency in research, we strongly recommend that all research is registered but for non-clinical trials this is not currently mandatory.

If a sponsor wishes to contest the need for registration they should contact Catherine Blewett (catherineblewett@nhs.net), the HRA does not, however, expect exceptions to be made. Guidance on where to register is provided within IRAS.

It is the responsibility of the sponsor to ensure that all the conditions are complied with before the start of the study or its initiation at a particular site (as applicable).

Ethical review of research sites

NHS sites

The favourable opinion applies to all NHS sites taking part in the study, subject to management permission being obtained from the NHS/HSC R&D office prior to the start of the study (see

A Research Ethics Committee established by the Health Research Authority

Appendix L: Letter from the Research Ethics Committee East of England – Hatfield

"Conditions of the favourable opinion" below).

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document	*Version*	*Date*
Copies of advertisement materials for research participants	2.0	19 February 2014
Covering letter on headed paper [NRES Letter]	2	05 August 2014
Covering letter on headed paper [NRES Letter]	1	26 August 2014
Evidence of Sponsor insurance or indemnity (non NHS Sponsors only)	Zurich Municipal Policy No NHE-09CA0 1-0013	22 May 2013
Letter from sponsor	Sue Steel	08 May 2014
Letters of invitation to participant	Consent to Share Details, Version 2.0	19 February 2014
Non-validated questionnaire [Demographic Details]	2.0	19 February 2014
Other [Protocol Presentation]	1	30 July 2014
Participant consent form	2.0	19 February 2014
Participant information sheet (PIS)	4.0	26 August 2014
REC Application Form	IRAS Version 3.5, 149582/6080 46/1/23	15 May 2014
Research protocol or project proposal [Research Protocol]	4	26 August 2014
Summary CV for Chief Investigator (CI)	Graham Beales	
Summary CV for Chief Investigator (CI)	Peter Langdon	01 March 2014
Summary CV for supervisor (student research)	Lynne Roper	20 May 2014
Validated questionnaire [AQ 10-item]		

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

After ethical review

Reporting requirements

The attached document *"After ethical review – guidance for researchers"* gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

A Research Ethics Committee established by the Health Research Authority

Appendix L: Letter from the Research Ethics Committee East of England – Hatfield

- Notifying substantial amendments
- Adding new sites and investigators
- Notification of serious breaches of the protocol
- Progress and safety reports
- Notifying the end of the study

The HRA website also provides guidance on these topics, which is updated in the light of changes in reporting requirements or procedures.

User Feedback

The Health Research Authority is continually striving to provide a high quality service to all applicants and sponsors. You are invited to give your view of the service you have received and the application procedure. If you wish to make your views known please use the feedback form available on the HRA website:
http://www.hra.nhs.uk/about-the-hra/governance/quality-assurance/

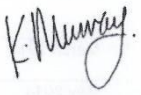
HRA Training

We are pleased to welcome researchers and R&D staff at our training days – see details at http://www.hra.nhs.uk/hra-training/

14/EE/0217	Please quote this number on all correspondence

With the Committee's best wishes for the success of this project.

Yours sincerely



pp.
Professor Barry Hunt
Chair

Email:nrescommittee.eastofengland-hatfield@nhs.net

Enclosures: *List of names and professions of members who were present at the meeting and those who submitted written comments*
"After ethical review – guidance for researchers" *[SL-AR2]*

Copy to: *Mrs Sue Steel, University of East Anglia*
Mr Paul Mills, NHS Suffolk

A Research Ethics Committee established by the Health Research Authority

Appendix L: Letter from the Research Ethics Committee East of England – Hatfield

NRES Committee East of England - Hatfield

Attendance at Sub-Committee of the REC meeting in Correspondence

Committee Members:

Name	*Profession*	*Present*	*Notes*
Mr David Grayson	Retired Local Government Administrator	Yes	
Professor Barry Hunt (Chair)	Pro-Vice Chancellor (International) (Retired)	Yes	
Dr Patricia Scott	Senior Lecturer DHRes	Yes	

Also in attendance:

Name	*Position (or reason for attending)*
Miss Kathryn Murray	REC Manager

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Appendix M: Letter from the Local Research and Development Office

Norfolk Community Health and Care NHS Trust

Ref: 2014LD01

Norfolk & Suffolk Primary & Community Care Research Office
Hosted by: South Norfolk CCG
Lakeside 400
Old Chapel Way
Broadland Business Park
Thorpe St Andrew
Norwich
NR7 0WG

Tel: 01603 257283

Fax: 01603 257292
E-mail: snccg.randdoffice@nhs.net
http://nspccro.nihr.ac.uk

Mr Graham Beales
Cambridgeshire and Peterborough Foundation Trust
University of East Anglia
Faculty of Medicine and Health Sciences
Norwich Research Park
Norwich Norfolk
NR4 7TJ
United Kingdom

28 August 2014

Dear Mr Graham Beales

Re: 2014LD01. Can training paradigms enhance global processing style in people with Asperger Syndrome? A randomised experiment

REC Number: 14/EE/0217

Chief Investigator: Mr Graham Beales

Sponsor: University of East Anglia

Further to your submission of the above project to the Norfolk & Suffolk Primary & Community Care Research Office your project has now been reviewed and all the mandatory research governance checks have been satisfied. I am therefore pleased to inform you on behalf of **Norfolk Community Health & Care NHS Trust** that NHS permission (R&D approval) was granted on **28th August 2014** for your study to take place at the following sites:

- Norfolk Community Health & Care NHS Trust

This is on the understanding that:

- Transfer of patient identifiable or confidential data must be in accordance with Trust policies.

You may now begin your study at the above sites. **Please note also, if you wish to extend approval to any sites other than those listed above you must apply for this through the Norfolk & Suffolk Primary & Community Care Research Office.**

NHS Permission is granted on the basis of the information supplied in the application form, protocol and supporting documentation, if anything subsequently comes to light that would cast doubts upon, or alter in any material way, any information contained in the original application, or a later amendment application there may be implications for continued NHS Permission.

Permission is granted on the understanding that the study is conducted in accordance with the Research Governance Framework and the terms of REC favourable opinion.

Appendix M: Letter from the Local Research and Development Office

If you have any queries regarding this or any other project please contact the research office at the above address. Please note, the reference number for this study is **2014LD01** and this should be quoted on all correspondence.

Yours sincerely

Clare Symms
Research Governance Manager, Norfolk & Suffolk Primary & Community Care Research Office
Signed on behalf of Norfolk Community Health & Care NHS Trust

cc: Mr Graham Beales, DClin Student, University of East Anglia
Sue Steel, Research Sponsor, University of East Anglia
Peter Langdon, Academic Supervisor, University of East Anglia

Conditions of NHS Permission
Please note the following conditions of NHS Permission - it is your responsibility to ensure that these conditions are disseminated to all parties involved in this project at the above sites.

You must notify the Norfolk & Suffolk Primary & Community Care Research Office of:

- All proposed changes to this study, whether minor or substantial
- All Serious Adverse Events relevant to the above sites
- Any deviations from the protocol or protocol breaches including any urgent safety measures that are required to be taken in order to protect research participants against any immediate hazard to their health or safety
- All incidents[1] or complaints in relation to the research project at the above sites
- Any Sponsor or funder initiated audits, or any regulatory inspections to be conducted in relation to this study at the above sites
- The study conclusion and/or termination of the study; where smartcards have been issued, this notification must be made on a site by site basis to allow deactivation of smartcards at that site.
- All publications relating to the study

Documentation:
You are required to maintain a site file for the study at your site. This should be maintained in accordance with ICH-GCP and will include as a minimum:

(a) Final approved protocol
(b) Copies of REC favourable opinion, NHS Permission letter relevant to your site, any other approvals necessary (e.g. MHRA)
(c) Participant information sheets, consent forms, invitation letters, posters/adverts and any other documentation given to the participant

It is your responsibility to update the information held at each site with any amendments made to this documentation and all approval letters applicable to those amendments and to ensure that all essential documents held at site are maintained, stored and archived as appropriate.

Scope of permission

- Please note that the above permission applies only to research activity on NHS staff or premises or involving NHS Patients and/or their tissues, data or samples. Separate agreements and permissions will be required for research involving private patients or those under the care of social services.

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[1] An incident is defined as any event or circumstance that could have, or did, lead to harm, loss or damage and includes loss of data, confidentiality breaches, harm to researchers or staff or damage to property.

2014LD01