THE UNIVERSITY OF HULL

(Re-)Conceptualisation in Autism Spectrum Disorders

Being a Thesis submitted for the Degree of

Doctor of Philosophy

in the University of Hull

by

Hollie Burnett

BSc (Hons) Psychology, University of Hull

October 2012

ABSTRACT

Background: Individuals with Autism Spectrum Disorder (ASD) have been shown to be compromised in cognitive flexibility and attentional switching. However, most studies that examine these executive functions did not distinguish between the ability to form new concepts and the ability to switch between concepts. Very few attempts have been made to disassociate them as separate abilities, or investigate whether the animate or inanimate nature of the concepts/objects affects these abilities. Further, very few switching tasks have investigated the autistic spectrum as a whole, with most studies focusing on severely autistic individuals.

Aims: The aim of this thesis was to explore individual limitations in the perceptual-cognitive abilities of forming concepts (conceptualisation) and of switching between concepts (reconceptualisation) in individuals with varying degrees of ASD and in typically-developed (TD) individuals. Further aims were: (i) Examine whether the animate or inanimate nature of the concepts affect the (re-)conceptualisation abilities, and whether this effect varies along the autism spectrum. (ii) Examine the impact of the 'salience of physical reality' on the (re-)conceptualisation abilities. (iii) Examine whether there is a continuum in concept forming and/or switching underlying the entire autism spectrum, extending into the TD population.

Methods: The basic experimental paradigm involved recognition of ambiguous and impoverished objects. Distinct animate and/or inanimate objects were morphed into each other, resulting in a sequence of interpolations with decreasing proportions of one object and increasing proportions of the other object. Participants had to identify the newly emerging object. There were two distinct versions: the Conceptualisation Task, in which participants had to form a new concept from 'scratch', and the Reconceptualisation Task, in which an existing concept had to be traded in for a new concept.

Participants: Three different clinical groups were tested: adults with Asperger's Syndrome (AS), children with AS, and children with autism. Each group and their control group, did not differ significantly in terms of age, sex or cognitive ability. In addition, on the basis of their score on the Autism Quotient (AQ), approximately the top and bottom 20% of the TD individuals were allocated to either a low or high AQ group.

Experiments: Four new experimental paradigms were employed: (Re-)Conceptualisation Silhouette Task *(see Chapters 2 and 3),* (Re-)conceptualisation Gabor Task *(see Chapter 4),* Delis-Kaplan Executive Functioning System (D-KEFS) Sorting Task with a unique added 'No Shuffle' condition, where the cards were not shuffled after each correct sort *(see Chapter 5)* and an Object-Ratio Task *(see Chapter 7)*. In addition, the performance of the participant groups on these new tasks was compared with their performance on existing concept-switching tasks that are part of the D-KEFS: the Trail Making Task and the Twenty Questions Task *(see Chapter 6).*

Results: In both the Silhouette and Gabor tasks, the ASD groups were significantly impaired in identifying concepts compared to TD groups, in both the conceptualisation and the reconceptualisation conditions. However, the deficit was largest when they first had to disengage attention (reconceptualisation), and when the object was animate. The autism group performed worse than the AS group, but only with respect to animate objects. Furthermore, when the start-object remained physically present (Gabor Tasks), or when the correctly made sort was not shuffled, but remained physically present until a new sort was made (Card Sorting Task), the ASD groups were even more impaired. Quite strikingly, this impairment specifically pertained to animate objects. In the TD population, differences were found between those with low and those with high AQ scores. In terms of performance on the (Re-)Conceptualisation Tasks, the high AQ group occupied a position in between the low AQ and AS groups.

Conclusions: Overall, the studies suggest that individuals with ASD are impaired in forming new concepts, especially when they first have to disengage their attention from a previously identified concept, and when the concept is animate. This deficit also extends to the TD population (to those TD individuals with high AQ scores). The findings therefore support the notion of a concept forming and concept switching continuum, that is present not only in ASD, but also in the general population. The findings further suggest that individuals with ASD possess a processing deficit specifically for animate concepts/objects, which becomes worse with increasing ASD severity.

ACKNOWLEDGMENTS

I am extremely thankful to my supervisor Tjeerd Jellema for all his support and guidance throughout the last few years in helping me to complete this thesis and for giving me the opportunity to study a PhD in an area of Psychology that truly fascinates me. I would also like to thank the individuals who participated in the research, the schools, universities and families that helped me with recruitment, in particular; Tracey Urquhart, Jenny Ravenhill, Amander Eaglen, Emma Cripps and Kris Trendall. I am grateful to members of the Psychology Department and the Graduate School at the University of Hull for facilitating me, teaching me and providing technical assistance throughout. I am also grateful to the Arts and Humanities Research Council for their financial assistance and providing me with the opportunity to attend courses and conferences that will continue to benefit me in my future career.

I would also like to Thank Johan Wagemans, Sven Panis and Bart Machielsen for their assistance and for computing the compactness and homogeneity scores for the silhouettes used in this study.

To my family, I would like to thank my friends and my siblings (Laith, Bethany, Lyle, Grace, Aoife and William) for enduring countless practice trials and pilot studies. And most of all, my Grandma and Grandad for supporting me and always being there. I love all very much.

PUBLICATIONS

Hartendorp, M. O., Van der Stigchel, S., Burnett, H. G., Jellema, T., & Postma, A. (2008). 'The Influence of Priming on the Interpretation of an Ambiguous Figure'. *Perception, 38,* 120-121.

Hartendorp, M. O., Van der Stigchel, S., Burnett, H. G., Jellema, T., Eiliers, P. H. C., & Postma, A. (2010). Categorical Perception of Concrete Objects Using a Free-Naming Experiment. *Visual Cognition*, *18*, 1320-1347.

Hudson, M., Burnett, H. G., & Jellema, T. (2010). Anticipating Action Sequences Based on the Actors Gaze Direction in Individuals with High-Functioning Autism Spectrum Disorder. *Perception, 39,* 128.

Hartendorp, M. O., Van der Stigchel, S., Burnett, H. G., Jellema, T., & Postma, A. (2011). Categorization of Perceptual Uncertain Information: Do We Process the Non-Dominant Object in a Morphed Figure? (Submitted).

Burnett, H. G., & Jellema, T. (2012). (Re-)Conceptualisation in Asperger's Syndrome and Typical Individuals with Varying Degrees of Autistic-like Traits. *Journal of Autism and Developmental Disorders.* (In press).

Hudson, M., Burnett, H. G., & Jellema, T. (2012). Anticipation of Action Intentions in Autism Spectrum Disorder. *Journal of Autism and Developmental Disorder*. (In press).

Palumbo, L., Burnett, H. G., & Jellema T. (2011). Emotional Anticipation Shapes Social Perception. *Perception, 40,* (Suppl. S).

Slocombe, K. E., Alvarez, I., Branigan, H.P, Jellema, T., Burnett, H., Fischer, A., Li, Y. H., Garrod, S., & Levita, L. (in press). Linguistic alignment in adults with and without Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders.*

CONFERENCE PRESENTATIONS

Burnett, H. G., & Jellema, T. (2008). '(Re-)Conceptualisation in Typical Individuals and Individuals with Autism Spectrum Disorder (ASD)'. Autism Research Centre, Royal Society Conference, London, *October 6-7.*

Burnett, H. G., & Jellema, T. (2008). '(Re-)Conceptualisation in Typical and Autistic Individuals'. Invited Talk. Workshop "Boundaries of What the Mind can Reach", Funded by CNCC-ESF. Amsterdam, Free University, *February 26-28.*

Burnett, H. G., & Jellema, T. (2009). '(Re-)Conceptualisation in Autism, An Update'. Meeting of the Boundaries Group, ESF-CNCC programme. University of Leuven, Belgium. *July 4-6.*

Hartendorp, M. O., Van der Stigchel, S., Burnett, H. G., Jellema, T., & Postma, A., (2009). 'Are Both Interpretations of a Morphed Figure Processed? International Workshop on Mental Imagery, Spatial Cognition, and Language (MICL), University of Padova, Italy, *June 12.*

Hartendorp, M. O., Van der Stigchel, S., Burnett, H. G., Jellema, T., & Postma, A., (2009). 'The Effect of Context on the Processing of Morphed Figures'. Nederlandse Vereniging voor Psychonomie (Dutch Society for Psychonomics), Egmond aan Zee, The Netherlands, *December 18-19.*

Burnett, H. G., & Jellema, T. (2009). '(Re-)Conceptualisation in Typical and Autistic Individuals'. "Boundaries of the Mind", Funded by CNCC-ESF. Edinburgh, Final Conference, *October 2-4.*

Burnett, H. G., & Jellema, T. (2010). '(Re-)Conceptualisation of Gaborised Objects in Typical Individuals and Individuals with Asperger's Syndrome'. Autism Research Centre, Cambridge, *September 10.*

Burnett, H. G., Panis, S., Wagemans, J. & Jellema, T. (2010). "The Forming of Concepts of Living and Non-Living Objects in Individuals with High-Functioning ASD". The Third Autism Neuroscience Conference, University of Cambridge, Cambridge, UK. *10 September.*

Hudson, M., Burnett, H. G., & Jellema, T. (2011). "Anticipating Others' Actions from Social Cues in Typically-Developed and Autistic Individuals." Experimental Psychological Society (EPS), Nottingham, UK. *6-8 July.*

TABLE OF CONTENTS

CHAPTER 1. (Re-)Conceptualisation in Autism Spectrum Disorders...........................12

Autism spectrum disorder 12

Theories underlying Autism Spectrum Disorder (ASD)..15

Autism Spectrum Disorder (ASD) and animacy..22

Concept forming and switching in Autism Spectrum Disorder..................................28

Summary 31

Aims of thesis...31

Main research questions..32

CHAPTER 2. Methodology..36

Cognitive ability tests...36

Autism assessment/ screening tests...41

Overview of thesis tasks…...43

CHAPTER 3. (Re-)Conceptualisation of Silhouette Objects in Asperger's Syndrome and Typical Individuals with Varying Degrees of Autistic-Like Traits...........................57

Introduction...57

Method...60

Results...68

Discussion..73

Summary..78

CHAPTER 4. (Re-)Conceptualisation of Silhouette Objects in Children with and without Autism Spectrum Disorder..80

Introduction...80

Method...85

Results....89

Discussion....96

Summary....100

CHAPTER 5. (Re-)Conceptualisation of Gaborised Objects in Asperger's Syndrome and Typical Individuals....102

Introduction....103

Method....108

Results....114

Discussion....121

Summary....126

CHAPTER 6. A Modification of the D-KEFS Sorting Task: Concept Formation versus Concept Switching in Individuals with and without Autism Spectrum Disorders. "The Salience of Physical Reality"....128

Introduction....129

Method....133

Results....141

Discussion....144

Summary....147

CHAPTER 7: The D-KEFS Trail Making and Twenty Questions Tasks....148

Participants....148

Procedure....150

1. The Trail Making Task....151

Results....152

2. The Twenty Questions Task....152

Results....154

Discussion....155

CHAPTER 8. The RATIO TASKS....157

1. The Ratio Picture Task....157

Participants....157

Procedure....158

Results....160

2. The Ratio Word Task....161

Participants....162

Procedure....163

Results....163

Discussion....164

CHAPTER 9: General Discussion....166

Results....167

Answered questions....169

Conclusions and future research....177

REFERENCES....178

APPENDIX....201

The ADOS....201

CHAPTER 1. (Re-)Conceptualisation in Autism Spectrum Disorders

Autism Spectrum Disorders

The term ‘autism’ was originally coined by Eugen Bleuler (1911) to describe the lack of social responsiveness and egocentrical absorption he observed in schizophrenic patients. The name ‘autism’ derives from the Greek word ‘autos’ meaning ‘self’, and ‘ism’ meaning ‘orientation’ or ‘state’. This describes the tendency to be absorbed in oneself; a condition where one’s thoughts, feelings and desires are governed by one’s internal representation of the world (Reber, 1995). Later, Kanner (1943) and Asperger (1944) categorised autism as what they believed to be a distinct developmental disorder. They noted that classic cases of autism showed severe problems in verbal and non-verbal communication, were indulged in repetitive behaviours and unable to join in group play (Wing, 1993).

Currently, autism is described as a pervasive developmental disorder along with Asperger’s Syndrome, Rett Syndrome and Childhood Disintegrative Disorder (International Classification of Diseases ICD-10, World Health Organisation, WHO 1992). As there is extreme variability between individuals diagnosed with autism, it is often referred to as a spectrum or continuum on which each individual in the clinical and typical population occupies a position, depending on the severity and number of autistic-like traits they possess (Baron-Cohen et al., 2001; *see Figure 1.1*).

Figure 1.1. The Autism Spectrum. Classic autism (left) has the most profound symptoms, followed by high functioning autism, and Asperger’s Syndrome. Typically developed

individuals are also thought to occupy a position on this continuum, depending on the extent to which they possess autistic-like traits.

Autism

Kanner (1958) originally described autism symptoms to include abnormalities of reciprocal social interaction and communication, and a wanting for routine or ‘sameness’. Currently, autism is defined as a pervasive developmental disorder, characterised by impairments in social and communicative development and by restricted interests and activities (ICD-10, WHO, 1992; American Psychiatric Association: APA 2000). The syndrome has been identified in all parts of the world and is four to five times more prevalent in males than females (Ritvo & Freeman, 1978), although recent research suggests that the male/female ratio could be up to 2:1 (Mattila et al., 2007). The qualitative impairments in social interaction include deficits such as failing to develop peer relationships, a lack of spontaneously seeking to share enjoyment, interests with others and a lack of emotional reciprocity. Non-verbal behavioural deficits include impairments in the use, and understanding of, eye gaze, facial expression and body posture. The qualitative impairments in communication manifest in a delay in, or lack of, social language, or in an impaired ability to initiate or sustain a relationship with others. There is a lack of spontaneous language and is typically repetitive and lacks variety. Children with autism may show a lack of make believe or social imitative play. Individuals with autism display restricted interests and activities that are abnormal in nature. They may seem apparently inflexible to specific, non-functional routines. They may develop rituals or stereotyped and repetitive mechanisms, such as finger flapping, rocking and persistent preoccupations with parts of objects (APA, 2000).

Asperger's Syndrome

Kanner and Asperger both noted that some individuals who were verbally bright showed similar but rather less extreme impairments than those with autism and labelled these individuals were labelled as having 'Asperger's Syndrome' (Frith, 1989). Asperger's Syndrome (AS) is a type of pervasive developmental disorder, included in the ICD-10 (WHO, 1992) and the Diagnostic Statistical Manual of Mental Disorders Four: DSM-IV (APA, 2000), characterised by deficits in reciprocal social interaction, unusual verbal and non-verbal communication and the presence of idiosyncratic isolated interests. Individuals with Asperger's Syndrome have an intelligence that is within the average range and above (80+) and have no significant gap or delay in language development.

The diagnosis of AS is currently under review (DSM-V, 2012). There is some speculation that autism and AS will be replaced by a more concise diagnostic criteria of 'Autism Spectrum Disorder' (ASD). It is expected that there will be several 'tiers' of severity in the new 'ASD' (DSM-V, 2012). Some clinicians have preferred the label 'high functioning autism' instead of AS (Venter, Lord & Schopler, 1992; Rumsey & Hamburger, 1988), or in addition to AS. However it is not clear whether high-functioning refers to high verbal, or non-verbal, intelligence, or perhaps to relatively high social adaptation regardless of intelligence (Frith, 2003).

High Functioning Autism

High functioning autism (HFA) is used to describe individuals who have symptoms that overlap with both autism and AS (Macintosh & Dissanayke, 2004). Individuals with HFA are by definition more cognitively able than those with autism, but still have the language impairments that individuals with AS do not have. It is suggested that the differences between HFA and AS are predominantly the cognitive function, current symptomology and early developmental history (Ozonoff, South & Miller, 2000). Individuals with AS generally demonstrate less severe early symptoms, a milder developmental course and a better out-come, than individuals with HFA. Overall, AS and HFA involve the same fundamental symptomology, differing only in early language development.

Theories Underlying ASD

Theory of Mind

It is suggested that some of the social and cognitive deficits in autism can best be explained by a lack of 'Theory of Mind'. The Theory of Mind (ToM; Baron-Cohen, 1995) postulates that a critical step in a child's development is the recognition that other individuals have knowledge, perceptions, and intentions that differ from their own. It is believed to be instrumental in establishing self-recognition, linguistic acquisition, and possibly in the development of imaginative and creative play (Byrne & Whiten, 1998). These meta-representational abilities allow an individual to mind-read and thus understand the actions and expressions of others within an intentional or goal directed frame work (Scassellati, 2000).

The Mindreading System

It is argued that there are four components to the human mindreading system: The Intentionality Detector, Eye Direction Detector, Shared Attention Mechanism, and Theory of Mind Mechanism (Baron Cohen, 1994, 1995).

The Intentionality Detector is a perceptual device that interprets motion stimuli in terms of the primitive volitional mental states of goal and desire. The Intentionality Detector essentially works through vision, touch and sound. The Eye Direction Detector also works primarily through vision by detecting the presence of eyes or eye-like stimuli, it computes whether eyes are directed toward the individual or to something else. The Eye Direction

Detector helps an individual to understand that if an organism's eyes are directed at something then that organism sees that thing. It is argued that the Shared Attention Mechanism builds a triadic representation via the Eye Direction Detector and that the representation can be visual or can contain one of the Intentionality Detector's terms (e.g. 'wants' or 'has goal'). The Theory of Mind Mechanism is thought to receive an input from the Intentionality Detector and Eye Direction Detector and to integrate the mental states into a useful theory. The Shared Attention Mechanism's triadic representations form an ideal input to Theory of Mind Mechanism, because the relationship can also take attitude terms (e.g. desire, attend, goal).

Theory of Mind and Autism

Some theorists (e.g. Tager-Flusberg & Sullivan, 1995; Baron-Cohen, 1995) argue that individuals with autism lack a 'theory of mind', which means that they are unable to attribute mental states to others or understand that others think or have feelings, and that these may be different from one's own. ToM (Baron-Cohen, 1995) emphasizes the social deficits in ASD and sees an inability to attribute epistemic mental states to others (and oneself) as one of its main 'causes'. Thus, it is argued that individuals with ASD suffer from 'mindblindness' (Baron-Cohen & Swettenham, 1997). As Cowley (1995) described it, 'Their worlds are peopled not by fellow beings with thoughts, feelings and agendas but by skin-covered bags that approach and withdraw unexpectedly'.

Williams et al. (2005) argue that the inability to form a theory of mind is due to an altered pattern of brain activity during the imitation of others. This is theorised to affect the individual's integration between activity in areas serving visual, motor and emotional functions.

Mindblindness

Mindblindness refers to the inability to imagine or represent states of mind such as thoughts, beliefs, knowledge, desires and intentions, which underlie most behaviour. It is argued that individuals with mindblindness do not have a mentalistic framework, or, as Dennett (1987) describes it, an ‘intentional stance’. When trying to interpret others’ behaviour, the mindblind individual is thrown back on temporal-regularity accounts, on routine script explanations or is forced to use unwieldy things resembling the ‘reinforcement schedule’.

According to Baron Cohen (1995), damage to the mindreading systems Shared Attention Mechanism or Theory of Mind Mechanism results in mindblindness, which underlies autism. This can be contrasted with other developmental disorders such as Down Syndrome, where all four modules are still evident (e.g. Scassellati, 2000). There is some evidence that the Intentionality Detector and Eye Direction Detector are however still intact in ASD (e.g. Tager-Flusberg, 1993; Hobson, 1993; Baron-Cohen et al., 2000). However, the Shared Attention Mechanism does not appear to be working through any modality; vision, touch, or audition. Children with autism often do not show any of the main forms of joint attention behaviour such as gaze monitoring (Loveland & Landry, 1986; Mundy et al., 1986; Leekan, et al., 1993) and using the pointing gesture (Curcio, 1978; Mundy et al., 1986; Baron-Cohen, 1989).

Wimmer and Perner (1983) devised a study to measure false belief, called the ‘Sally-Anne Task’. There were two protagonists used, ‘Sally’ and ‘Anne’. Sally was shown to place a marble in her basket. When Sally left the room, Anne moved the marble in her basket. When Sally returned to the room the experimenter asked the child ‘Where will Sally look for the marble?’ and ‘Where is the marble really?’. Children with autism showed great difficulties in this task, scoring significantly lower than Down Syndrome and typically developed children, answering that Sally would look in Anne’s basket (Hobson, 1993).

The Sally-Anne Task demonstrates how children with autism have difficulty in understanding epistemic belief. Although most children with autism fail tests of belief and understanding, such as the ‘Sally-Anne Task, a minority do pass. These children are seen as a ‘talented minority’ (Frith, 1986). However, passing the Sally-Anne task does not imply normal ToM, since most false belief tasks are set at an equivalent mental age of about 3-4 years (e.g. Baron-Cohen, 1989).

Various suggestions as to alternative mechanisms that mediate the core symptoms of autism have been put forward (e.g. Frith, 2001). A main criticism of the ToM hypothesis is that it exclusively applies to social deficits, ignoring other characteristic deficiencies in domains such as language, imagination and motor behaviour (Volkmar et al., 2004). Furthermore, it is argued that ToM does not explain the superior skills that people with ASD may have. Not only children with ASD have shown ToM deficits, deaf children with no signing parents, are also severely delayed in their ability to pass the false belief task (Peterson & Siegal, 2000). Hobson (1987) rejects the ToM as explanation for the social deficits in autism. He argues that the lack of interpersonal skills in autism and the deficit in identifying animate objects occur because of the presence of inanimate objects.

The ToM lays down an interesting framework, attempting to explain the mindreading system with support for each of the different components of the mindreading system (e.g. Hainline, 1978; Pratt & Bryant, 1990; Reddy, 1991; Baron-Cohen et al., 2000). Baron-Cohen and Sweetenham (1997) also demonstrates how specific deficits to components Shared Attention Mechanism and Theory of Mind Mechanism can result in mindblindness. Autism is shown in this theory to be unique from other developmental disorders such as Down Syndrome.

The Mirror Neuron Hypothesis

The mirror neuron hypothesis proposes that mirror mechanisms enable the automatic embodied simulation of other’s actions and emotions (Gallese & Goldman, 1998; Rizzolatti & Sinigaglia, 2008). Mirror neurons were first discovered in the premotor cortex of the macaque monkey (Di Pellegrino et al., 1992; Gallese et al.,1996; Rizzolatti et al., 1996).

They fired when the monkey performed a goal directed action and when the monkey observed someone else executing the same action. Subsequently, imaging studies in humans found mirror mechanisms in the inferior frontal gyrus/ventral pre-motor cortices and inferior parietal lobe, which has led researchers to regard these areas as the homologous mirror neuron system (MNS) in humans (Rizzolatti & Craighero, 2004).

Mirror mechanisms provide a plausible neurophysiological mechanism for a variety of social behaviours, from imitation to empathy (Gallese & Goldman, 1998; Rizzolatti, Fogassi & Gallese, 2001; Iacoboni & Dapretto, 2006; Rizzolatti & Sinigaglia, 2008). Imitation is the most widely used form of learning during development (Iacoboni & Dapretto, 2006). It is also thought to be central to the development of fundamental social skills such as reading facial expressions, gestures and desires of other people (Hurley & Carter, 2005).

Evidence for a role of the MNS in empathy come for example from studies showing that the anterior insular and inferior frontal cortex become active when a person experiences emotion and when they see another person experiencing emotion (Lamm, Batson & Decety, 2007; Botvinick et al., 2005; Cheng et al., 2008). It is also argued that the MNS helps us to understand intention (Fogassi et al., 2005). The monkey's inferior parietal lobe was active when the monkey watched an experimenter grasp an apple and put it to the mouth but not when he put it in a cup, suggesting the cells coded for the intention to eat (Fogassi et al., 2005).

It is not normally possible to study single neurons in the human brain, so scientists cannot be certain that humans have mirror neurons. However, the results of imaging experiments have shown that the human inferior frontal cortex and part of the parietal cortex are active when the subject recorded from performs a certain action, but also when he/she sees another individual performing the same action (e.g. Fadiga et al., 1995). Therefore these regions are likely to contain a mirror neuron mechanism (MNM). It was further shown that conducting an action and imagining to conduct that action activated the same areas, located in the mirror neuron system (Decety, 1996).

The recent finding of mirror neuron mechanisms supports simulation theories, particularly those which argue that we implicitly understand others' actions and intentions (Gallese & Goldman, 1998). A possible function of this system might be to enable an organism to detect certain mental states of observed co-specifics. As humans have been shown to rely heavily on non-verbal communication cues in order to evaluate the social communicative intentions of others some theories have argued that mirror neurons may be part of or a precursor to, a more general mindreading ability (Gallese & Goldman, 1998).

Mirror Neurons in Autism

The mirror neuron hypothesis argues that there is a specific neural substrate, located bilaterally in the frontal premotor cortex and the lateral inferior parietal cortex, malfunctioning of which is responsible for some of the social and cognitive deficits in autism (Williams et al., 2001). Recent data suggests that a dysfunction of the MNS in humans may lead to core social deficits in autism (Williams et al., 2001). Functional Magnetic Resonance Imaging (FMRI) studies support abnormalities in neuronal activity in the inferior frontal gyrus, an area associated with the MNM, suggesting that a dysfunctional MNM may underlie the social deficits observed in autism (Dapretto et al., 2006).

FMRI studies in individuals with ASD have shown abnormalities in response to animate objects in the superior temporal sulcus (STS) and focal regions of visual cortex, and abnormalities in response to inanimate objects in the middle temporal gyrus (MTG), left posterior middle temporal gyrus, inferior temporal sulcus (Oberman et al., 2005; Iacoboni & Dapretto, 2006).

In typical children, the mu rhythm (7-14 Hz) in Electroencephalogram (EEG) recordings from motor areas are suppressed when the child watches another person move, which is believed to reflect activity in the premotor mirror area, while this suppression is not present in children with autism (Oberman et al., 2005). This suggests that in children with autism the mirror neuron areas were less activated when observing others. In *f*MRI studies investigating cortical activity during imitation, activity attributed to mirror neurons in the right partial lobe (Williams et al., 2005), and also activity in the STS (Iacoboni & Dapretto, 2006), have been found to be reduced in ASD compared with typical individuals. Based on these results, some researchers claim that core deficits in autism are caused by a deficient MNM, leading to disabilities in social skills, imitation, empathy and theory of mind (Gallese & Goldman, 1998; Williams et al., 2005).

The role of the MNS and the STS in the perception of animacy.

The MNS hypothesis postulates that there is a specific system for processing social stimuli. Single cell studies in the primate brain and imaging studies of the human brain also suggest that similar areas of the brain (i.e. STS) contain specialised cells for the processing of animated objects and their actions (Adolphs, 1999; Alison, Pruce & McCarthy, 2000). Single cell studies have stressed the importance of the STS, pre-motor cortex, inferior frontal gyrus (region F5) and the inferior parietal lobe in analysing visual cues derived from bodily actions, suggesting a specific role for these brain areas in the perception and understanding of animated objects (Jellema & Perrett, 2005; Rizzolatti & Craighero, 2004). Single-unit studies in macaque monkeys show that the STS is maximally activated by bodily form and bodily actions conveyed by agents (Oram & Perrett, 1996). In contrast, non-biological control objects have been found to be ineffective in the STS (Perrett et al., 1989).

Interestingly, human imaging studies provided evidence for the existence of separate and distinct neural substrates for animate and inanimate objects and their motions. Such studies showed that the motions of non-living objects (such as tools, e.g. a pair of scissors opening and closing) activated an area in the temporal lobe (the middle temporal gyrus and the inferior temporal sulcus), which is distinct from the STS (Beauchamp et al., 2003). These temporal lobe areas are likely candidates for the forming of concepts of animated and non-animated objects, respectively.

ASD and animacy

For example, (aspects of) social cognition - i.e. the part of cognition that deals with living or animate objects and the social cues they convey - can be selectively impaired, amongst many other spared (or even enhanced) cognitive abilities, as in ASD, or can be selectively enhanced, amongst many impaired cognitive abilities as in Williams syndrome (Frith, 2001). The ToM hypothesises that there is a deficit in processing social cues in ASD. This is also supported by the finding of cells in the human and animal brain that are sensitive to social stimuli. The MNS hypothesis also found that specific animate categories can be located to more specific brain regions.

Animacy

This thesis will describe ‘animate’ and ‘inanimate’ objects. The reason for this is that ‘animate’ refers to a living thing (e.g. birds, fish, insects, bodies, mammals and reptiles) and ‘inanimate’ refers to a non-living object (e.g. cars, chairs, musical instruments, foods and clothes) (Downing et al., 2004). The term ‘social’ is not used as this would refer more to an interaction. Previous studies, involving similar animate (i.e. animal) or inanimate objects (i.e. tools), use a similar description (e.g. Chao, Weisberg & Martin, 2002). For the purpose of this thesis we will refer to biological objects, presented statically as ‘animate’.

There is further behavioural, neurological and anecdotal evidence that supports the distinction of animate objects and the deficits in ASD.

Behavioural studies

There evidence noted above, suggests that social cue processing forms a separate and distinct kind of processing. There are several studies indicating that specifically social cues are processed less efficiently in ASD. For example, compared with typical children, children with ASD have been found to show social unresponsiveness and unusual communication patterns (Charman et al., 1997). A marked deficit has also being found in the processing of biological motion (Rutherford, Pennington & Rogers, 2006) and biologically-relevant stimuli conveyed by living agents (Blake et al., 2003).

Children with ASD have been shown to be more interested in inanimate objects than human beings; when matching video tapes of people and videos of non-human stimuli (bird, dog, train, car) autistic children were much poorer at matching human stimuli (Hobson, 1987). Similarly, children with autism have also been found to be better at discriminating between pictures of buildings than pictures of faces (Boucher & Lewis, 1992; Boucher, Lewis & Collins, 1998).

Brain studies

Areas such as the amygdala, ventromedial frontal cortices, and right somatosensory-related cortex are thought to comprise the so called ‘social brain (Brothers,1990; Dunbar, 1998). Also, single cell studies in the monkey brain have been particularly influential by stressing the importance of e.g. the STS in analyzing visual cues derived from bodily actions, suggesting a specific role for the STS in the perception and understanding of animated objects (Jellema & Perrett, 2005, 2007). Imaging studies in humans confirmed this role for the STS (e.g. Allison et al., 2000; Beauchamp et al., 2003).. The STS has been shown to be compromised in ASD in response to animate objects (Oberman et al., 2005; Iacoboni & Dapretto, 2006).

Anecdotal evidence

Anecdotal evidence suggests that children with ASD are more interested in inanimate objects than in human beings. Young children diagnosed with autism have been found to be more interested in mechanical toys such as cars and trucks than in social toys such as dolls, compared to typical children of the same sex (Charman et al., 1997). Autistic individuals may seem to treat others as if they were objects, rather than human beings. For example, an individual with ASD may use the other's hands as a tool, by guiding it toward a container to open (Curcio, 1978). At a crowded beach an autistic child wanting to go towards the sea may simply step on the bodies of sunbathing people that happen to lie in its path to the sea (Frith, 1989). Kanner and Lesser (1958) described a child with autism to be 'aware of people….but considers them not differently from the way he (or she) considers the desk, bookshelf, or filling cabinet'. Autistic individuals may attach the same emotional value to inanimate objects as to human beings, for example, the sale of the family car is like the loss of a family member (Cesaroni & Garber, 1991).

Two other, more generally applicable theories are the Central Coherence theory, which postulates a preference for local over global processing (Happé & Frith, 2006) and the Executive Functioning theory, which focuses on deficits in planning and monitoring of behaviour, cognitive switching and other executive skills (Russell, 1998; Russell, Jarold & Hood, 1999). Both approaches still view social dysfunction as one of the manifestations of the general underlying deficiency, but hypothesise that a general style or information processing deficit increases the difficulty..

The Central Coherence Theory

Some theorists argue that although there may be a general attentional deficit in autism, that individuals with autism tend to focus on local details (i.e. elements constituting an object), at the expense of processing global or contextual information (Frith, 1989; 2003). This theory argues that the inability to pull together several strands of information in order to process it for higher-level meaning is the core deficit in autism (e.g. Hill & Frith, 2003; Happe & Frith, 2006).

Children with autism often fail in tasks that involve central coherence (Baron-Cohen & Sweetenham, 1997). Autistic individuals have been shown to be better than typical subjects at searching for a part of an object, in tasks such as the Embedded Figure Task (Shah & Frith, 1983; Jolliffe & Baron-Cohen, 1997) and on a subset of the Wechsler intelligence scale, the Block Design Task (Shah & Frith, 1983). This has led some to argue that the cognitive deficits reported in autism reflect a difference in cognitive processing style (Happé, 1999). Frith (1989) argues that the superior ability on the Embedded Figures Test seen in autism and on an unsegmented version of the Block Design Test arises because of a relative immunity to context effects in autism. Children with autism have also been found to be equally good at judging the identity of familiar faces in photographs, whether they are given the whole face or just part of the face. Non-autistic controls show a `global advantage' on such a test, performing significantly better when given the whole face, not just the parts of the face (Campbell, Baron-Cohen & Walker, 1995).

The central coherence account of autism is beneficial in having the potential to explain the non-holistic, piece-meal perceptual style characteristic of autism and the unusual cognitive profile seen in this condition (including the islets of ability) (Baron-Cohen & Sweetenham, 1997).

The Executive Dysfunction Theory

In an early model, Stuss and Benson (1986) claimed that there are four specific components to executive functioning; anticipation, goal selection, preplanning and monitoring. Later revisions investigate more general executive functioning components which include flexibility and inhibition (e.g. Russell, Jarold & Hood, 1999; Pellicano, 2006, 2007; Hill, 2004). Executive functioning is the postulated mechanism which enables the typical person to shift attention flexibly, inhibit proponent responses, generate goal-directed behaviour, and solve problems in a planned, strategic way (Baron-Cohen & Sweetenham, 1997). Cognitive flexibility is crucial for successful social interaction. It allows an individual to shift thoughts or actions flexibly depending on situational demands (e.g. Geurts, Corbett & Solomon, 2009).

Brain studies

Animal research and human lesion and imaging studies have found that some components of executive functions can be localized to specific areas of the brain, such as the pre-frontal cortex, when carrying out tasks that involve inhibition, working memory and social processing (e.g. Pellis & Pellis, 2006). Neuro-imaging studies in humans also support these findings (e.g. D'Esposito et al., 1995; Tulving et al., 1996). Patients with frontal lobe damage have been found to fail in tasks designed to measure executive functioning (e.g. Shallice, 1982). The cerebellum has also been suggested to be involved in attention switching, and, interestingly, autistic patients have been found to perform similarly to cerebellar damaged patients in attention switching tasks (Courchesne et al., 1994).

Autism

It has been suggested that individuals with ASD may not fail theory of mind tests because of a deficient ToM, but simply because they cannot "disengage from the salience of physical reality" (Hughes & Russell, 1993). Their responses are reality-driven; the fact that the marble actually is in Anne's basket overrides other possible responses. Thus they cannot apply their basically intact theory of mind to complex social situations, when those social situations require executive functioning skills, such as perceptual integration (Verbeke et al., 2005). The fundamental dysfunction is thus in the executive functioning, not in ToM. However, Baron-Cohen and Sweetenham (1997) argue that although individuals with autism evidently suffer from executive dysfunction, these deficits may co-occur with theory of mind deficits because of their shared frontal origin in the brain.

Individuals with ASD have being found to be impaired in various tasks involving executive functions i.e. the Wisconsin Card Sorting Task (Ozonoff, Pennington & Rogers, 1991), the Tower of Hanoi or London (Shallice, 1982), in which the subject has to solve problems by planning before acting (Hughes, Russell & Robbins, 1994) and the Verbal Fluency Test (Perret, 1974) in which the subject has to generate novel examples of words beginning with a given letter, in a fixed time period.

Some studies have aimed to modify executive functioning tasks for autistic individuals, such that they do not contain as many demanding social characteristics (e.g. Russell et al., 1999). Ozonoff (1995) found that an ASD group performed better on a computerized version of the Wisconsin Card Sorting Test than in the standard format. This computerised version did not involve any social or verbal demands and therefore is argued to measure executive functioning in autism more effectively. This was also found in children with high functioning autism, who made fewer correct card sorts and more errors in the traditional Wisconsin Card Sorting Test, than in the computerized version (Tsuchiya et al., 2004). Van Eylen et al (2011) also propose that performance of children with ASD is related to social demands and the degree of disengagement required to perform the switch.

Set shifting

Set shifting is thought to be an executive function measuring flexibility. It is defined as 'the frequent switching of one response pattern to another' (Ozonoff & McEvoy, 1994). An example of set shifting includes the Wisconsin Card Sorting Test (WCST: Milner, 1964), in which the subject has to shift flexibly between different card-sorting strategies. The WCST involves various other skills, such as concept formation, inhibition and working memory. In an attempt to isolate flexibility from inhibition, Ozonoff and McEvoy (1994) and later, Ozonoff and Strayer (1997), modified the task and found that individuals with HFA performed as well as the controls at inhibition, but were significantly impaired in set shifting. Another task by

Courchesne et al (1994) found that individuals with ASD show a deficit in attention shifting, when making aterations of attention between two different sensory modalities.

Concept forming and switching in ASD

Previous studies investigating set shifting (i.e. Ozonoff & McEvoy, 1994) involve switching between a previously identified pattern/rule or commonality between objects to identifying a new pattern or rule. The tasks described in this thesis will describe a similar procedure, but will describe it as 'concept forming/switching'. It should also be noted that the terms 'concept formation' and 'object identification' are used largely interchangeably. However, the task requirements are such, that 'concept formation' seems more appropriate than 'set shifting' or 'object identification'. Generally speaking, a 'concept' refers to a mental representation that summarises all the properties, relations and structures that the members of a category have in common and which distinguish them from the members of other categories (Johnson & Ratkinson, 2006). Thus concepts are abstractions that identify commonalities according to certain principles or rules (Bruner, Goodnow & Austin, 1967), and refer especially to prototypical representations of object categories rather than specific exemplars of an object category.

We use the term 'concept forming' as referring to the ability to form new concepts from scratch, and the term 'concept switching' as referring to the ability to flexibly switch from one concept to another involving disengagement of attention from a concept held in mind. As such, they could be considered as two distinct executive functions. They have nevertheless typically been studied as one function, with little attempts to disassociate them (e.g. Delis et al., 2001). They are especially difficult to disentangle in tasks where multiple stimuli are presented simultaneously.

Concept switching inevitably involves attention switching. A brain region often implicated in attention switching is the pre-frontal cortex (Miller & Cohen, 2002), but also the cerebellum has been implicated, especially in relation to autism as individuals with ASD show similar patterns of impairment in shifting attention to individuals with cerebellar lesions (Courchesne et al., 1994).

Possible deficiencies in cognitive switching/flexibility have been studied predominantly in individuals with low-functioning ASD. The general consensus is that this group exhibits problems in disengaging attention. For example, when presented with multiple stimuli, autistic children tend to remain fixated on the first stimulus (Hughes & Russell, 1993), make fewer eye movements between stimuli (Swettenham et al., 1998; Landry & Bryson, 2004) and show compromised focused attention (Kaland, Smith & Mortensen, 2008). However, it is not known whether individuals with HFA or AS have similar deficiencies, nor is it known whether the deficiency extends into the TD population. It has been suggested that individuals with HFA may suffer from attention switching deficits, but to a lesser extent than those with severe forms of autism (Kleinhans, Akshoomoff & Delis, 2005).

Support for concept forming and switching deficits in ASD are noted in behavioural, neurological studies and anacdotal evidence.

Behavioural studies

Concept-switching per se has not been studied extensively in ASD, although there is a wealth of experimental evidence showing that switching of behavioural patterns is impaired in autism; these behavioural patterns are typically rigid and repetitive (Frith, 1989). Some studies indicate that disengagement of attention is compromised in ASD (Courchesne et al., 1994; Hughes & Russell, 1993; Wilson et al., 2006; Kaland, Smith & Mortensen, 2008). Landry and Bryson (2004) showed that when presented with multiple stimuli, autistic children remain fixated on the first stimulus. Individuals with autism have been found to make less frequent shifts in attention between living things than between non-living objects (Swettenham et al., 1998), suggesting that they may be more interested in non-living objects than living things. It supports Baron Cohen’s idea of a deficit in ASD in neuro-cognitive mechanisms dedicated to the processing of social information such as direction of eye gaze (the Eye Direction Detector) and joint attention (Shared Attention Mechanism).

Landry and Bryson (2004) measured eye gaze in two conditions. In the first condition the participant had to shift their attention from one stimulus to another, while in the second condition the stimuli were presented simultaneously. Only in the second condition, autistic children showed a profound deficit in disengaging visual attention. However, they performed similarly to typical children and children with Down's syndrome when shifting their attention to a stimulus by removing the competing one. This finding is consistent with typically developing two month old children, who show sticky visual attention, failing to disengage from a stimulus as flexibly as older children (Hood & Atkinson, 1993).

Brain studies

Tasks involving concept switching are often thought to involve the frontal cortex. Other areas implicated are the superior prefrontal cortex and posterior parietal cortex (Sohn et al., 2000). Autistic children and cerebellum damaged patients have been found to show similar deficits in tasks requiring rapid and accurate shifts of attention between auditory and visual stimuli (Courchesne et al.,1994). Gomot et al (2008) found children with autism to show reduced activation of the left anterior cingulate cortex and reduced activation in the bilateral temporo-parietal region and in the right inferior and middle frontal areas in a task involving passive detection of infrequently occurring frequency-deviant and complex novel sounds. In the latter study, abnormalities were found involving a cortical network known to have a role in attention switching and attentional resource distribution.

Anecdotal Evidence

There is further ample anecdotal evidence from teachers and care-givers working with ASD suggesting that the inflexibility not only exists at the behavioural level, but also at the cognitive level. The cognitive inflexibility seems to coexist with ‘peculiar’ obsessions (for example with specific objects or parts of objects). As well as this need for routines and rituals, it is frequently reported anecdotally that some stimuli trigger sustained periods of obsessive attentional focus, to the exclusion of other stimuli, even when these other stimuli are perceptually salient (Plaisted, O’ Riordan & Baron-Cohen, 1998).

Summary

Individuals with ASD have been shown to be compromised in processing social cues (e.g. Hobson, 1987; Boucher & Lewis, 1992) and have been suggested to suffer from ‘sticky attention’ (Courchesne et al., 1994). The previous set shifting and attentional flexibility tasks set out an interesting theory, suggesting an underlying cognitive flexibility deficit, supported by behavioural and neurological studies and anecdotal evidence – that individuals with ASD engage in repetitive and rigid behaviours. Most previous tasks involve multiple stimuli being presented simultaneously, (e.g the WCST). It has therefore being difficult to separate executive functions (e.g. Delis et al., 2001). Studies investigating attentional flexibility or set shifting have not previously made a distinction between the ability to switch between concepts and the ability to form concepts, and largely involved working memory. Futhurmore, between category differences (i.e. animate vs. inanimate) are not investigated. It is also not known if the deficit in cognitive flexibilty varies depending on the severity of ASD symptoms the individual has, no previous concept switching tasks investigating the autistic spectrum as a whole, mainly focusing on severely autistic individuals and children (e.g. Hughes & Russell, 1993; Sweetenham et al., 1998).

Aims of Thesis

This thesis aims to investigate attentional flexibility in ASD by investigating the forming of new concepts from scratch (conceptualisation) and the ability to flexibly switch from one concept to another (reconceptualisation). Another specific aim is to find out if the differences between TD and ASD in identifying animate/inanimate objects is due to an enhanced/impaired access to either category. A further aim is to investigate whether individuals with varying degrees of ASD (autism and AS) and TD individuals with varying degrees of autistic-like traits perform differently on Conceptualisation and Reconceptualisation Tasks. This allows us to investigate whether there is a continuum in the autism spectrum in much greater detail.

Main research questions:

1 *Does it make a difference whether the forming of a new concept involves trading in an existing concept for a new one, or whether the new concept is formed from 'scratch'? In other words, are forming and switching two distinct and different abilities? Are they differently affected in ASD?*

It is aimed to investigate whether it made a difference if individuals with ASD have to visually disengage from one concept before identifying a new one. In order to understand another agent's mind one needs to be able to switch mental concepts rapidly, because the other agent's mental states, intentions and feelings may also change rapidly. The ToM model (Baron-Cohen, 1995) postulates that social understanding often involves some sort of hypothesis testing for example: an individual forms an idea about another's intention and then tests this idea and then looks for further evidence that will either corroborate or falsify it. Falsifying implies that the previous concept needs to be traded in for a new one. This process clearly requires one to be flexible in re-conceptualisation. The inability to do so may be one reason why for autistic people it is impossible to keep up with the pace of social exchanges. This does not exclude the possibility, however, that the forming of new concepts *per se* (from scratch) is intact in ASD.

2 Is the forming of a new concept affected by the animate or inanimate nature of the concept?

Several neurological (e.g. Downing et al., 2004), behavioural (e.g. Hobson, 1987; Frith & Frith, 1999) and anecdotal (e.g. Kanner & Lesser, 1958) studies support the idea that individuals with ASD are impaired in the forming of animate concepts but are relatively unimpaired in forming inanimate concepts (cf. Boucher & Lewis, 1992). A specific deficit in forming animate concepts would be in line with the ideas of an impaired 'social brain' in ASD.

3 Does it make a difference whether the distractor object (i.e. the object one has to disengage from) remains physically present during the time the new object has to be identified?

The physical reality can be quite salient for individuals with autism (Hughes & Russell, 1993), possibly so much so that they cannot escape from it. An aim was to investigate the impact of the physical reality on the ability to disengage (i.e. one object remaining physically present) and form a new concept (i.e. whilst another object appears simultaneously).

4 *Do individuals that occupy different positions on the autism spectrum (low Autism Quotient, high Autism Quotient, Asperger's syndrome, autism) differ in their ability to form new concepts?*

A futhur aim was to investigate whether there is an underlying continuum in concept switching in the typically-developed (TD) population, and whether this is correlated with the extent to which TD Individuals possess autistic-like traits as measured by the Autism spectrum Quotient (AQ, Baron-Cohen, 2002). It has been suggested that in the normal, non-patient, population large differences already exist in the ability to switch between concepts

(Verstijnen & Wagemans, 2006). It is possible that each individual occupies a position on an underlying continuum in concept switching, ranging from very poor to very adept, with individuals with ASD at the extreme poor end of the continuum and typical individuals with low AQ scores at the extreme low end.

5 *If differences are found between the recognition of animate and inanimate objects (or concepts), was it then due to enhanced or impaired access to the animate or inanimate categories?*

In principle, a difference in the recognition of animate versus inanimate objects between the different TD and clinical participants groups could be due to either an impairment with respect to one category of objects, or to an enhancement with respect to the other category of objects, or to both.

6 *Do the ASD groups differ from typical individuals in their local versus global processing style? Are they significantly more impaired when having to identify an object for which only global information is available?*

It was also aimed to investigate whether the presumed deficit in individuals with ASD in the global processing of objects affects their ability to conceptualise and/or to reconceptualise. The idea is that by restricting the amount of local information, any deficit they may have with respect to concept forming/switching will be brought out in the open.

7 *How does the clinical population in this study perform on already established concept formation and switching tasks?*

Finally it was aimed to investigate how individuals with ASD perform on concept switching tasks that have already been established in the literature and are routinely used as measures of executive functioning, such as the Delis Kaplan Executive Functioning System (D-KEFS). Three relevant sub tests of the D-KEFS will be used: The Card Sorting Task, The Twenty Questions Task and the Trail Making Task, and their results on these tasks will be compared with results on our own, newly designed, tasks.

CHAPTER 2: Methodology

Periodic, medical, neurological, psychological, educational and behavioural measures are necessary for any autism assessment (Ritvo & Freeman, 1978). Although all subjects described in this thesis as having Autism Spectrum Disorder (ASD) had previously received a diagnosis of either autism or Asperger's syndrome (AS) from a clinical psychologist, it was important to establish that all of the participants in this group met the ASD criteria using the same standardised autism screening tools by the same examiner. It was further important to make sure that the control group did not differ in cognitive ability and did not meet the ASD criteria. It was also important to quantify the extent of autistic traits possessed by each individual in the control group in order to rank them and create sub-groups of individuals based on an autistic spectrum (i.e. high or low in autistic traits). It was also investigated how a sample of our ASD and control participants performed on existing concept formation and switching tasks in comparison to our own novel paradigms.

This chapter aims to give an overview of the cognitive tests, autism screening tools and the tasks administered to the ASD and control groups in this thesis.

The Cognitive Ability Tests

Language and Communication Problems for Individuals with Autism

A diagnosis of autism requires an individual to have language and communication difficulties (Rutter & Sohopler, 1978). In autistic disorder, the rate of intellectual disability (defined as IQ below 70) is 70 - 90% (Gillberg, 1995; American Psychiatric Association: APA, 2000; Scott, Clark & Brady, 2000; Chakrabarti & Fombonne, 2005), with 15% having an IQ of below 50 (Nordin & Gillberg, 1996). Difficulties with conventional language acquisition have been blamed for impairments in social interactions as well as increased behavioural problems (Carr & Durand, 1985; Koegel, 1995). It is estimated that without intervention 21-61% of children with autism would not develop language and communication (Woods & Wetherby, 2003). In AS, however, there is no language delay and intellectual disability is rare, usually not differing significantly from the general population (Gillberg & Gillberg, 1989; Ehlers et al., 1997).

As a majority of the experiments described in this thesis require a verbal response made by the participant, it was important to establish the general cognitive and language ability for all children and adults with ASD in order to accurately match them to typically developed (TD) and learning disabled controls. The cognitive tests used to assess the participants in this thesis were the Wechsler Adult Intelligence Scale: WAIS-III (Wechsler, 1997),Cognitive Ability Test: CAT-3 (Lohman, Hagen & Thorndike, 1995) and Wechsler Intelligence Scale for Children: WISC-III (Wechsler, 1991).

Adult Cognitive Ability Tests

- *The Wechsler Adult Intelligence Scale (WAIS-III)*

The WAIS-III (Wechsler, 1997) is the most common cognitive assessment used for assessing the intelligence of TD adults and adults with ASD. The WAIS-III provides scores for Verbal IQ, Non-Verbal (Performance) IQ, and Full Scale IQ, along with four secondary indices (Verbal Comprehension, Working Memory, Perceptual Organization, and Processing Speed) *(see Figure 2.1).* The Wechsler tests have yielded a fairly consistent profile in autism (Frith, 1989), with superior performance on the block design and extremely poor performance on the picture arrangement and comprehension tasks. Results of the performance tests are usually better than those of verbal tests. The WAIS-III takes around 90 minutes to complete.

All the adults in the clinical and TD groups described in this thesis were university students with a diagnosis of AS or high functioning autism (HFA). As no previous cognitive test scores were available prior to participation, all of the clinical group and a number of the

TD group completed the WAIS-III with the examiner (HB), taking around 90 minutes to complete. They were found to have an IQ of average or above average. Neither group displayed any language difficulties and did not vary significantly in verbal or non-verbal ability.

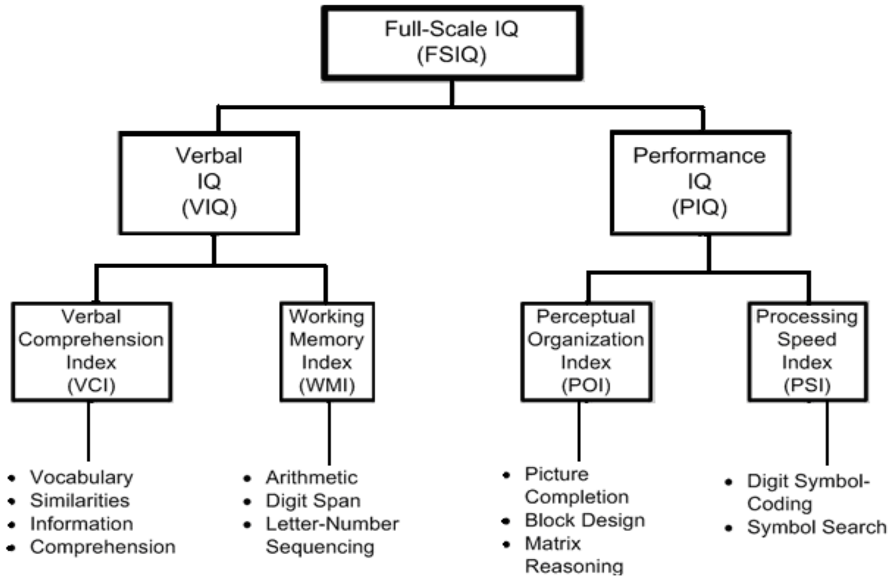

Figure 2.1. The Wechsler Intelligence Scale Three; Full Scale IQ, comprising of Verbal, Non-Verbal Scales. The Four Subscales include; Verbal Comprehension, Working memory, Perceptual Organisation and Processing Speed.

Child Cognitive Ability Tests

The individual children with ASD who participated varied quite widely in the severity of autistic symptoms, as well as in their overall intellectual ability. Therefore the children were separated into groups based on the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DiLavore & Risi, 1999) criteria for either autism or AS. As individuals with AS have been found to have a similar cognitive ability to that of TD individuals (Gillberg & Gillberg, 1989; Ehlers et al., 1997), a less in depth cognitive test was required. All children with AS and TD children completed the CAT-3 with a class teacher prior to taking part in the study. The CAT-3 involves fewer subtests and is therefore is much shorter and less time consuming than the WISC-III. As children with autism required a significantly more in-depth cognitive assessment the WISC-III (Wechsler, 1991) was administered for this participant group and the low-functioning control group.

- *Cognitive Ability Test (CAT-3)*

The CAT-3 comprises 3 scales, measuring Verbal Reasoning (VR), Non-Verbal Reasoning (NVR) and Total-Quantative Reasoning (QR). The CAT-3 has been found to be a reliable routine school-based method of assessing intellectual functioning in children and when compared with the WISC-III it has been found correlate much more strongly than any other cognitive test (Yeates & Taylor, 1997). The CAT-3 is an assessment of a range of reasoning skills; words, numbers and shapes or figures, such as verbal, quantitative and non-verbal reasoning. The group of children who met the criteria for AS, came from mainstream schools. Therefore their CAT-3 scores, which were completed at school with their class teacher, were obtained. The scores were determined to be within the average cognitive ability range.

- *The Wechsler Intelligence Scale for Children (WISC-III)*

For the group of children who met the criteria for autism, displaying a higher number of autistic symptoms on the ADOS, their cognitive ability was assessed using the WISC-III, with the examiner (HB) or an Educational Psychologist. This test was administered because the children in this group displayed profound social and communicative deficits on the ADOS. The WISC-III is determined as an appropriate cognitive test for children suspected of having learning difficulties. It is also the most common cognitive assessments used for assessing the intelligence of children with ASD. The WISC-III, like the WAIS-III, provides scores for Verbal IQ, Non-Verbal (Performance) IQ, and Full Scale IQ, along with four secondary indices (Verbal Comprehension, Working Memory, Perceptual Organization, and Processing Speed) *(see Figure 2.1 and 2.2)* and takes around 90 minutes to complete.

There-fore it gives a more in depth cognitive profile than tests such as the CAT-3 asit allows the examiner to assess the individual's language ability, using sub-tests such as vocabulary, to investigate whether the participant is suitable to take part in the study. This group, as well as the autism group, were described to be 'low functioning' in terms of their cognitive ability; a low measure of intelligence (American Association of Mental Retardation: AAMR, 1973; British Psychological Society: BPS, 2001). Their IQ ranged between 49 and 91, with an average of 72 (SD =12.3). Individuals described to be significantly impaired have an intelligence range between 55-69; in the UK they are allocated intermittent or limited support from local authorities. Severely impaired individuals are allocated extensive and pervasive support and have an intelligence range below 55, measured by the Wechsler Intelligence Scale (BPS, 2001).

	GROUP	N	ASSESSMENT	IQ-T	IQ-V	IQ-P	RANGE
ADULTS	AS	25	WAIS-III	117.2 (9.8)	119.1 (13.7)	112.2 (14.5)	95-140
	TD	29	WAIS-III	112.6 (8.8)	113.5 (7.9)	110.3 (12.2)	100-129
CHILDREN	AS	15	CAT-3	94.1 (13.6)	94.1 (11.4)	94.9 (13.1)	82-127
	HF Control	16	CAT-3	107.5 (8.0)	106.6 (12.1)	108.4 (13.3)	98-123
	Autism	15	WISC-III	72.3 (12.3)	73.4 (14.9)	75.5 (13.0)	50-96
	LF Control	15	WISC-III	71.7 (12.7)	74.8 (15.4)	68.8 (14.3)	49-91

Table 2.2. All Cognitively assessed participant characteristics. The adult and child ASD and control groups. The Assessment used; the Wechsler Adult Intelligence Scale (WAIS-III), Cognitive Ability Test (CAT-3) and Wechsler Intelligence Scale for Children (WISC-III). The cognitive tests, mean scores are given for the total over all IQ (IQ-T), Verbal IQ (IQ-V) and Non-Verbal/ Perceptual IQ (IQ-P). The standard deviations are displayed between the brackets. The range from lowest to highest IQ-T are displayed for each group.

Autism Assessments/Screening Tests

Any autism assessment must uncover abnormalities in all three impairments to warrant a diagnosis of autism. When assessing an individual for autism spectrum disorder (ASD) it is important to establish that delays and abnormal functioning are persistent and have had an onset prior to the age of three years and that the disturbances in development cannot be accounted for by a genetic disorder such as Rett's Syndrome (APA, 2000). In addition to assessing children and adults with an existing diagnosis of ASD, autism screening tests were important to use as a criterion to exclude children and adults who did not display the required autistic symptoms for 'Autism' or 'AS'. The screening tests were also administered to the control groups to be able to exclude children and adults who displayed high autistic-like traits. It was also important to use standardised autism screening tests with all participants in order to rank them in order of autistic traits, and to develop sub-groups of participants ('autistic' or AS').

The Autism Diagnostic Observation Schedule (ADOS)

The ADOS (Lord et al., 1999) is an advanced clinical instrument designed for the purpose of diagnosing ASD. As well as using the ADOS for clinical purposes, the ADOS may also be used to evaluate individuals and provide information for research purposes. Any individual who intends to use the ADOS for research purposes (in most locations) must have attended a training course and obtained a reliability level in administering the instrument in order to assess competently.

There are four ADOS modules. Module 1 is appropriate for children who are non-verbal or are using single words. Module 2 is appropriate for children using some flexible three word phrases. Module 3 is for children or adolescents who have good language skills, using some complex sentences and phrases in a complex variety of situations Module 4 is used for adolescents/adults who are fluent in language (s*ee Appendix 1).*

This thesis mainly concentrates on adolescents and adults who are fluent in language and use sentences and phrases in a variety of relatively complicated situations. The language may consist of some echoed utterances, stereotyped abnormalities associated with autism such as intonation, volume, rhythm and rate and idiosyncratic or stereotyped use of words and phrases. All individuals in the adult and child clinical groups and the control group of children who had learning difficulties, completed modules 3 or 4 of the ADOS with the examiner (HB) depending on their chronological age and language ability. If a participant was to start module 3 or 4 unsuccessfully, the examiner would drop down a module in order to make the assessment appropriate for the participant's developmental stage. In total four adult participants and no children participants were excluded on the basis of the ADOS criteria.

The Autism Quotient (AQ)

The Autism Quotient (AQ) is a brief, fifty-statement, self-administered questionnaire designed for measuring the degree to which an adult with normal intelligence has traits associated with ASD. Participants rate their own behaviour in terms of social skills, attention switching, attention to detail, communication and imagination on a four point scale (definitely agree, slightly agree, slightly disagree, definitely disagree). Although the AQ is not a diagnostic tool, a score of 32 or higher (out of 50) has been shown to correlate with ASD (Baron-Cohen et al., 2001; Wheelwright et al., 2006; Wakabyashi, Baron-Cohen & Wheelwright, 2006; Hoekstra et al., 2007).

The AQ is often used as a screening tool by psychologists for ASD, as it has been shown to be strongly correlated with ASD, with a score of more than 32 out of 50 being highly predictive of ASD (Baron-Cohen et al., 2001; Wheelwright et al., 2006; Wakabayashi, et al., 2005; Hoeksta et al., 2008). The Autism Quotient further supports the idea that autism is a spectrum that extends into the typical population, suggesting that each individual occupies a position on the scale, possessing varying levels of autistic characteristics.

Previous findings support the notion that individuals in more social faculties/professions, e.g. social workers and nurses, possess fewer autistic traits compared to those that are in more exact faculties/professions such as accountancy and engineering (Baron-Cohen et al., 2001). The AQ measure has been shown to be able to successfully discriminate between subgroups of a normal population in reflexive orienting tasks, where observing a face with averted eyes resulted in a (covert) reflexive shift of attention to the gazed at location (Bayliss & Tipper, 2005; Bayliss, Pellegrino, 2006); AQ scores correlated negatively with the ability to orient reflexively to such social cues.

In total one-hundred-and-two adult controls participated in the studies described in this thesis, for all of which the AQ was obtained (Mean AQ score of 16.1, SD = 6.3). The students that obtained AQ scores falling in approximately the top 20% and bottom 20% participated in the tasks described in this thesis (*see Chapter 3*, Silhouette Reconceptualisation Task).

The Adolescent Autism-Spectrum Quotient (Ad-AQ)

The Ad-AQ (Baron-Cohen et al., 2006) is a fifty-statement questionnaire designed for parents of children between the ages of 10-15 years, to measure the degree to which a child has traits associated with ASD. Like the adult AQ, the Ad-AQ has been used as a screening tool for ASD (e.g. Gomot et al., 2008). The Ad-AQ allowed us to screen the children in the control groups and filter out individuals with high autistic traits. No children were excluded on the basis of their Ad-AQ score.

OVERVIEW OF THESIS TASKS

The tasks described in this chapter will involve existing and new paradigms that are targeted to either concept formation or concept switching *(see Figure 2.3).* The novel paradigms are designed to disentangle these two abilities in separate tasks. These new tasks form the main part of the thesis. The basic experimental format involved a sequence of mixed-objects that had been interpolated between two distinct objects, the so called start and end-objects. The start and end-objects could be either animate or inanimate. All the interpolated objects contained varying percentages of the start and end objects (e.g. a sequence could consist of 100%A-0%B, 95%A-5%B, 90%A-10%B etc). The interpolations were achieved through morphing procedures at 5% or 10% change steps. It was the participant's task to identify the end-object as quickly as possible. This was very difficult for interpolated objects that contained low percentages of object B and became increasingly easier when the interpolated objects contained increasingly higher percentages of object B.

Basically, each task comes in two versions: a conceptualisation version (left side of *Figure 2.6*) in which a new concept has to be formed from scratch (no switching is involved), and a reconceptualisation version (right side of *Figure 2.3*), in which switching is involved as one concept has to be traded in for another one.

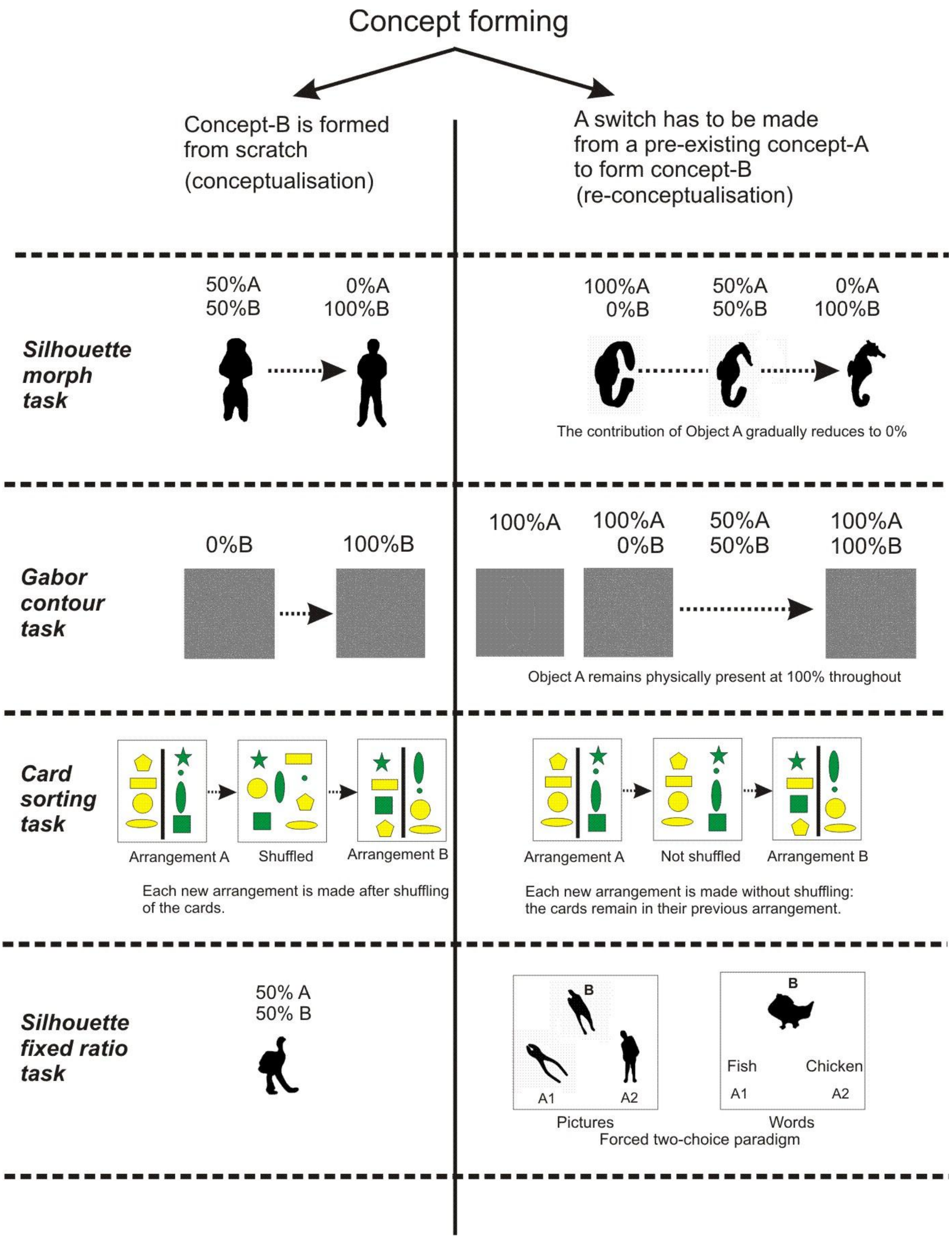

Figure 2.3. An overview of the new tasks used in this thesis. The tasks either involve concept forming (no switching; left side) or concept switching (right side). Note that this distinction between conceptualisation and reconceptualisation does not apply to the ratio task.

CHAPTERS 3,4 and 5: The (Re-)Conceptualisation Tasks

The (Re-)Conceptualisation studies involve two separate tasks that investigate the formation (conceptualisation) and switching (reconceptualisation) of animate and inanimate concepts. Chapter 3 investigates these paradigms using silhouette objects with adults with AS and typically developed adults that did not differ in cognitive ability. Chapter 4 investigates children with AS or autism and children that did not differ in cognitive ability, again using the silhouette objects. In Chapter 5 conceptualisation and reconceptualisation are investigated using Gaborised objects. In these Gabor (Re-)Conceptualisation Tasks the amount of local information available to the participant was decreased while the start-object remained physically present throughout the sequence. These manipulations were hypothesised to make both object identification and disengagement from the start-object more difficult for the ASD groups.

The Conceptualisation Silhouette Task (Chapters 3 and 4)

The morphing sequence started with an unidentifiable object consisting of 50% object A and 50% object B, i.e. midway of full sequence. For the participant, this object had an arbitrary form (resembling an ink blob). The object then morphed into object B (i.e. the contribution of object A gradually decreased and that of object B gradually increased). Each picture was presented for 3 s and was then immediately followed by the next one. In this task the participant thus started off without a concept in mind. The number of interpolations needed to give the correct answer was recorded, as were all incorrect guesses (object interpolations are displayed in *Figure 2.4*).

The Reconceptualisation Silhouette Task (Chapters 3 and 4)

The morphing sequence started with 100% object A (0% object B). The participant was asked to name this object, so as to ensure that this concept was in the participant's mind at the start of the sequence. As the sequence developed, the contribution of object A gradually decreased and that of object B gradually increased until 100% object B (and 0% object A) was reached. Again, the number of interpolations needed to correctly name the emerging object, plus all incorrect guesses, were recorded. In this paradigm the participant thus started off with a specific concept in mind, and a reconceptualisation needed to take place. In other words, concept A had to be traded in for concept B. (object interpolations are displayed in *Figure 2.5*).

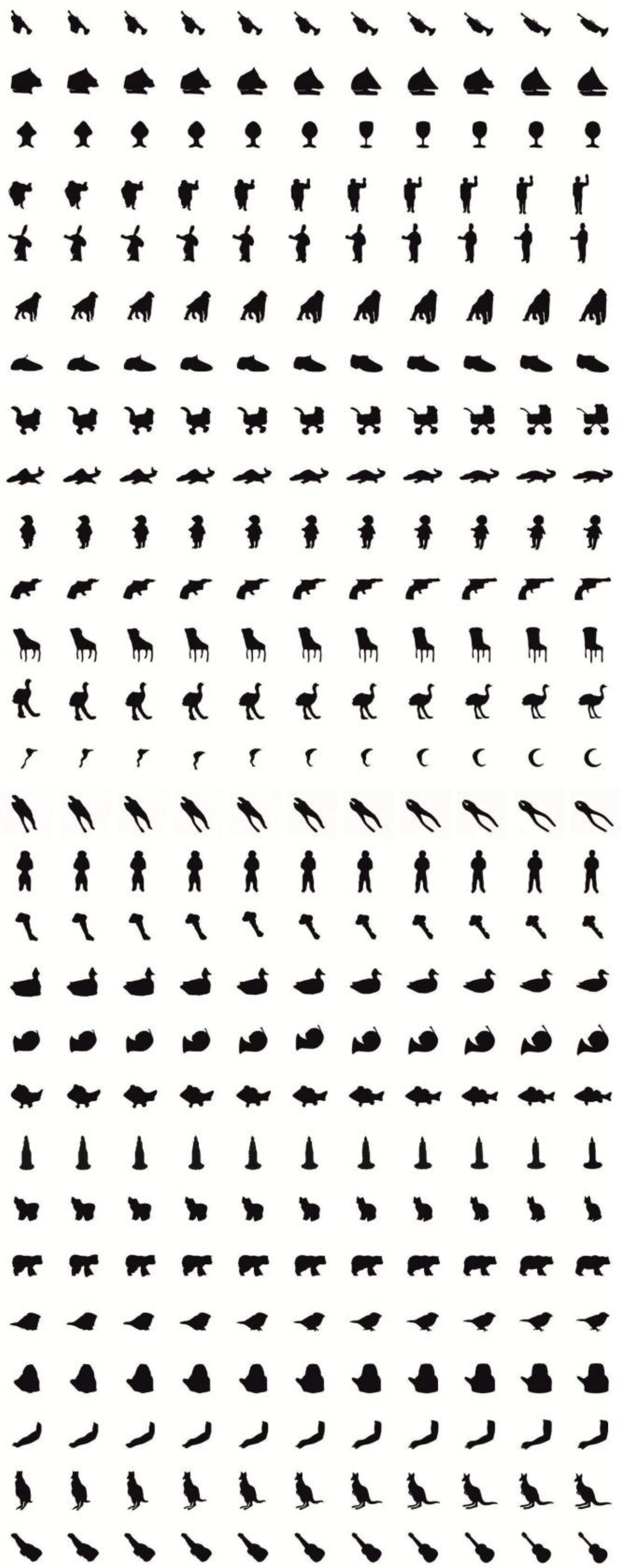

Figure 2.4. Object interpolations in the Conceptualisation Task, objects containing 50% object A and 50% object B are on the far left, and objects containing 0% object A and 100% object B are on the far right.

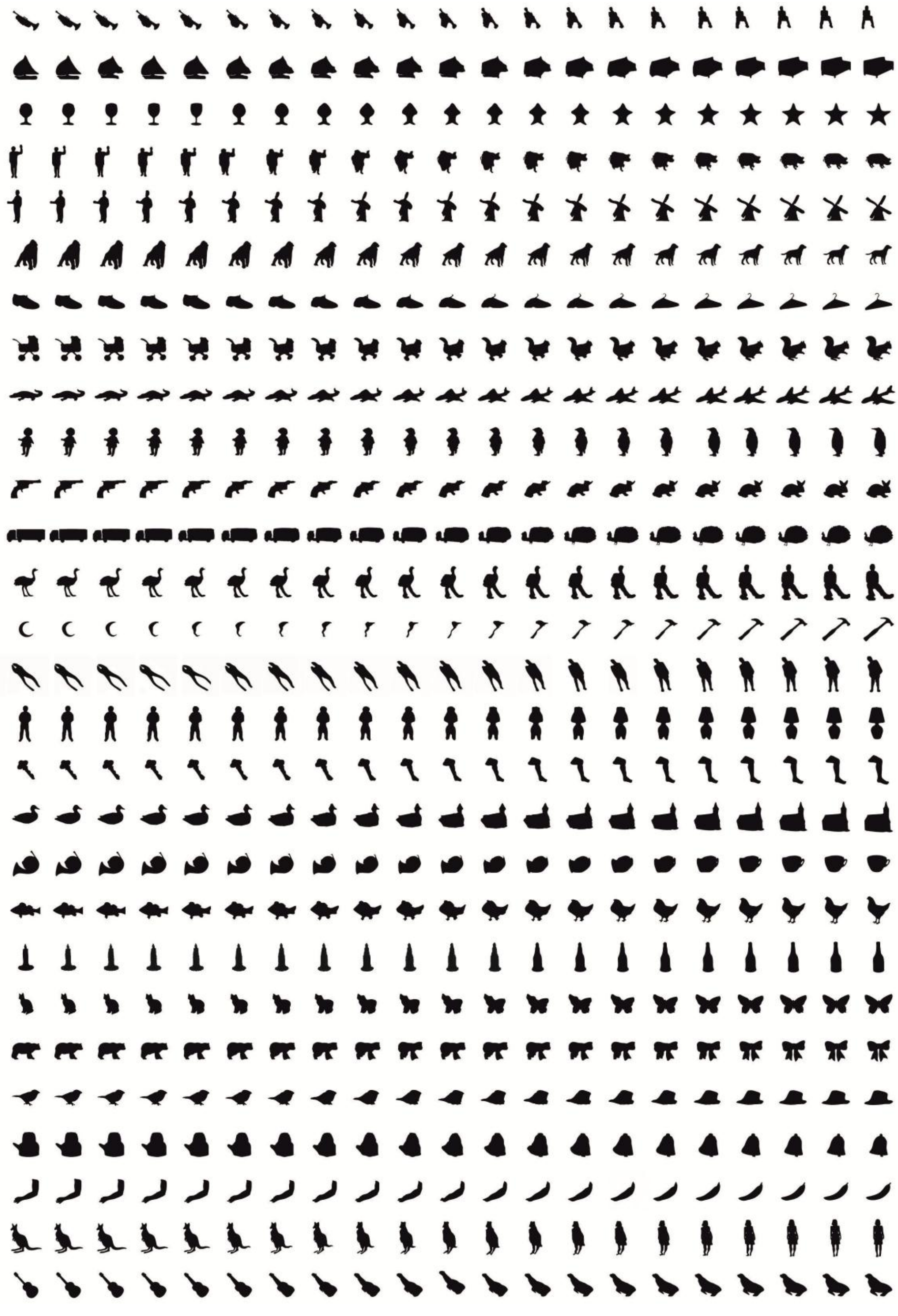

Figure 2.5. Object interpolations in the Reconceptualisation Task. Objects containing100% object A and 0% object B are on the far left, and objects containing 0% object A and 100% object B are on the far right.

The Conceptualisation Gabor Task (Chapter 5)

The sequence started with an unidentifiable object. For the participant, the screen was filled with small lines (Gabors) *(see Figure 2.6)*, some of which gradually rotated to form the contour of an object, so that the shape of the object slowly emerged. The first 10 pictures were shown in a rapid succession of 1 frame per second, starting with frame 11 (50%), each picture was presented for 2 seconds and was then immediately followed by the next one (ISI = 0 ms). In this task the participant thus started off without a concept in mind. The number of interpolations needed to give the correct answer was recorded, as were all incorrect guesses.

The Reconceptualisation Gabor Task (Chapter 5)

The sequence started with 100% object A (0% object B*; see Figure 2.6*). The participant was asked to name object A, so as to ensure that this concept was in the participant's mind at the start of the sequence. As the sequence developed, the object A remained present while in the background of this object, object B gradually emerged until 100% object B (and 100% object A) was reached. The first 10 pictures were again, shown in a rapid succession of 1 frame per second. Starting from frame 11 (100% A / 50% B) the pictures were shown at a rate of 1 per second. Again, the number of interpolations needed to correctly name the emerging object, plus all incorrect guesses, were recorded. In this paradigm the participant thus started off with a specific concept in mind, and a reconceptualisation needed to take place.

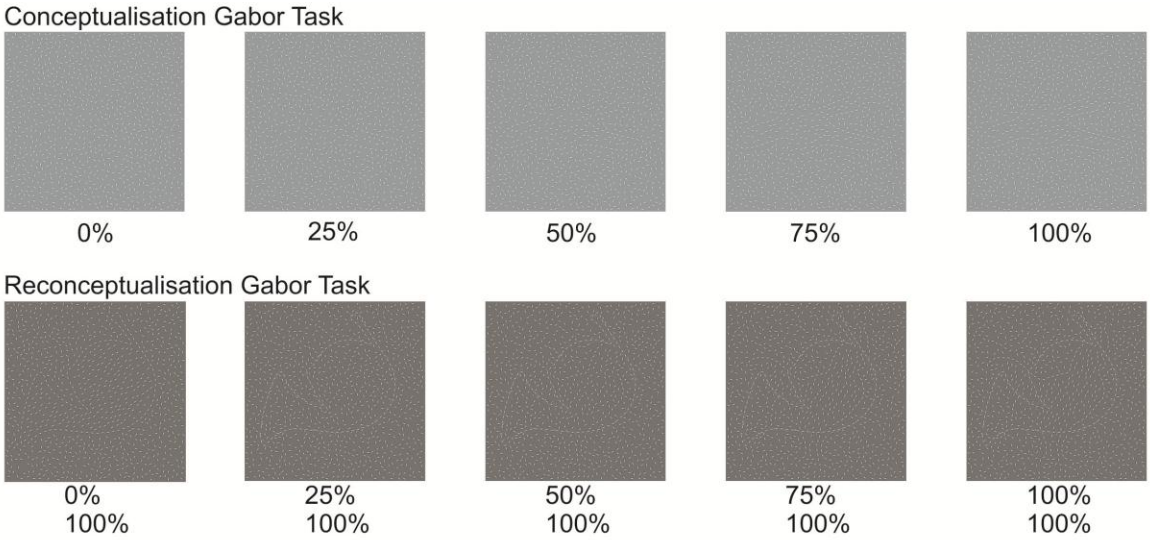

Figure 2.6. The object interpolations in the Conceptualisation Gabor Task (top) 0% object B is on the far left and 100% object B is on the far right. The Reconceptualisation Gabor Task, 100% object A and 0% object B are on the far left and 100% object A and 100% object B are on the far right.

CHAPTER 6: The Card Sorting Task

The D-KEFS Card Sorting Task is an assessment designed for measuring multiple components of concept-formation and problem solving abilities. The D-KEFS typically incorporates 16 different sorting concepts across two sets of cards (3 per set), it involves two testing conditions: Free Sorting and Sort Recognition. Prior to the test, a screening test is administered to establish that the examinee can read and understand the printed words on the sorting task. For Condition 1: Free Sorting, the examinee is presented with six mixed-up cards (all six card laid out in front of the examinee) that display both stimulus words and various perceptual features and thereby gives the examinee the option of using verbal or non-verbal strategies to sort the cards.

The cards are mixed up by the examiner into a random order, in an oval arrangement. The examinee is asked to sort the cards into two groups, three cards per group, according to as many different categorisation rules or concepts as possible, and to describe the concept he or she has used to generate each sort. Each of the two card sets can be grouped into a maximum of eight target sorts. Three sorts are based on verbal-semantic information from the stimulus words, and five are based on visual-spatial features or patterns on the cards. Right or wrong feedback is not provided during the test. The examinees performance is scored in terms of accuracy of the sort and the description.

For Condition 2, Sort Recognition, the same cards are sorted into 2 groups of 3 cards by the examiner and the examinee attempts to identify the correct categorisation rule or concept used to generate each sort.

The Sorting task provides a quantifiable measure of concept formation and the process of executive functions such as the ability to inhibit previous sorting responses in

order to engage in flexibility of behaviour, and the ability to inhibit previous description responses in order to engage in flexibility of thinking. In the unilateral lesions in the cerebral regions posterior to the frontal lobules that disrupt either fundamental language skills or visual-spatial abilities may have more of an effect on the modality of concept-formation favoured on the ability to generate sorting rules per se (Crouch, Greve & Brooks, 1996).

On both the Wisconsin Card Sorting Task and Delis Kaplan Card Sorting Task individuals with ASD have shown profound deficits in forming and switching concepts (Landy & Bryson, 2004; Kleinhans et al., 2005). In our study we modified the procedure of the card sorting task to incorporate a ‘no shuffle’ condition *(see Figure 2.7).* The purpose of this was to determine whether individuals were hampered in concept formation by first having to visually disengage from a previously formed sort that remained physically present during the time they were thinking about a new way to sort the cards.

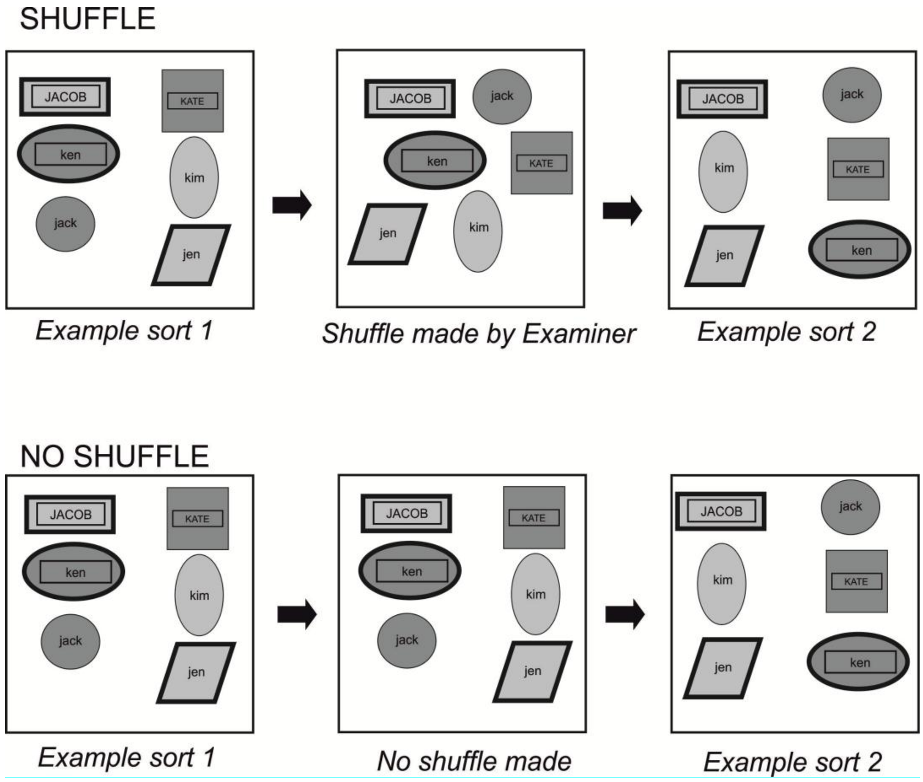

Figure 2.7. Example of the card sorting set. The cards are separated into two groups, based on shape; squares are on the left and circles are on the right.

CHAPTER 7: The D-KEFS Trail Making and Twenty Questions Task

Two tasks from the Delis-Kaplan Executive Functioning System (D-KEFS) (Delis, Kaplan & Kramer, 2001) were selected that aim to measure concept forming (Twenty Questions Task) and concept switching (Trail Making Task). The aim of this was to investigate how the children and adults with AS perform on already established tasks, measuring cognitive flexibility.

- *The Twenty Questions Task*

The D-KEFS Twenty Questions Task is designed to measure concept formation, The examinee is presented with a stimulus page depicting pictures of 30 common objects and is instructed to ask the fewest number of yes/no questions in order to identify the unknown target object. The 30 common objects can be subsumed into various categories and subcategories that include varying numbers of objects. For example, the category *living things* has 15 objects, *animals* has 8 objects, and *birds* has 3 objects *(see Figure 2.8)*.

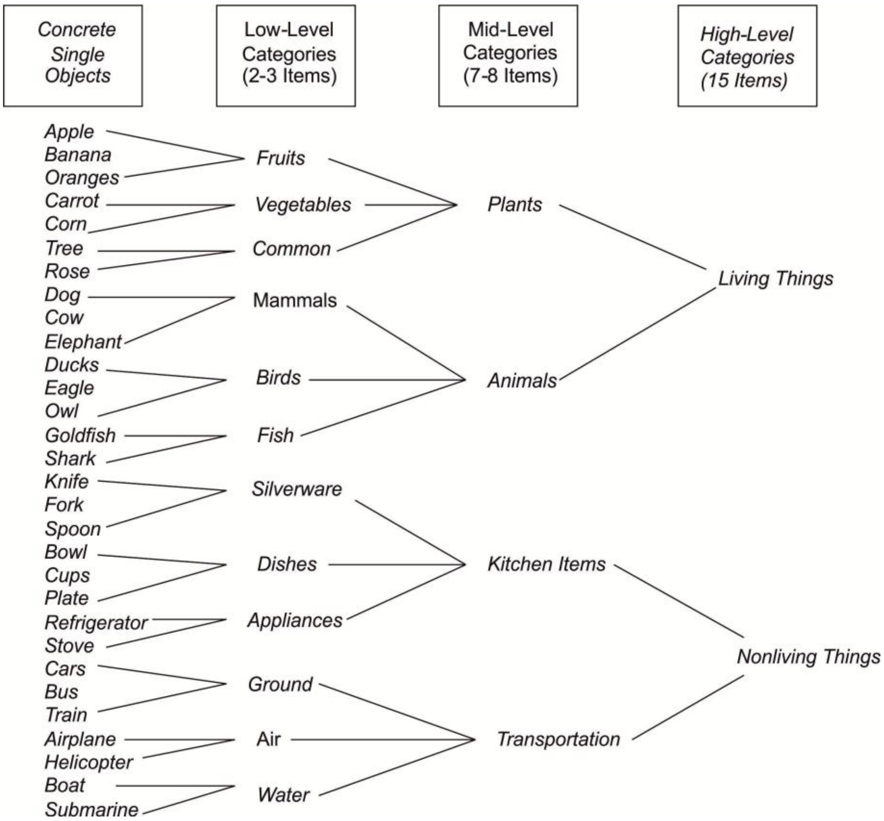

Figure 2.8. The 30 items (left) which the participant can see on the stimuli book. There are 3 levels of categories (low, mid and high) that the participant may use in order to work out the object that the examiner has chosen.

- *The Trail Making Task*

The Trail Making Task consists of five conditions. The primary executive functioning task is the number-letter switching condition (Part B), a visual-motor sequencing procedure, which is a measure for flexibility of thinking *(see Figure 2.9).* Four other novel conditions of the D-KEFS test (Part A) were also administered. These allow the examiner to quantify and derive normative data for several key component processes needed to perform the switching task (each takes only 30-60 seconds to administer). These fundamental components include visual scanning, number sequencing, letter sequencing and motor speed in drawing lines. In this way, the examiner can assess empirically whether a deficiency in the switching condition is related to a higher level deficit in cognitive flexibility.

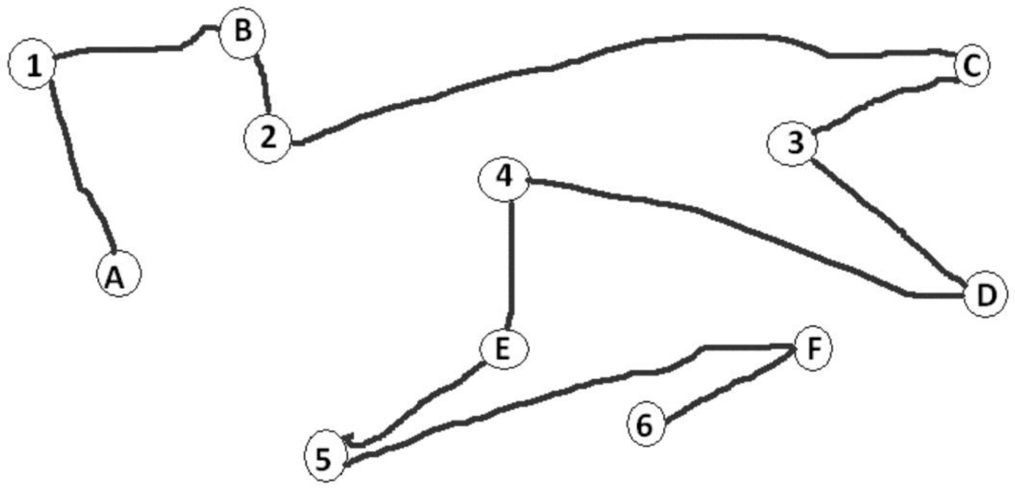

Figure 2.9. The participant is asked to join the letters and numbers together in order, starting with a number followed by a letter, starting with the lowest number and letter (A-1-B-2-C-3-D-4 and so on).

CHAPTER 8: The Ratio Tasks

The Ratio Tasks involve two separate tasks, using either pictures (Ratio Picture Task) or words (Ratio Word Task) to choose from. Crucial in the Ratio tasks is that the participant does not need to generate guesses, and thus does not need to access different object categories, as in the Silhouette and Gabor (Re-)Conceptualisation Tasks. This is because two possible end-objects (B1 and B2) are already provided, one of which contains a higher percentage of object A than the other.The participant was presented with an ambiguous (morphed) interpolation of two objects (objects A and B) on a computer screen (50% of objects was animate and 50% was inanimate). The interpolated object contained either 40%A-60%B, 45%A-55%B, 50%A-50%B, 55%A-45%B or 40%A-60%B. *(see Figure*

2.10). The two objects (A and B) were presented below the interpolated object, at either end of a 5 point scale, and the participant is asked to indicate whether the object is more similar to object A or object B on the scale by pressing a key from 1 to 5 (1 = 'mostly similar' to Object A, 2 = 'slightly similar' to object A, 3 = equally similar to objects A and B, 4 = 'slightly similar' to object B, 5 = 'mostly similar' to Object B). Half of the trials the animate object was presented on the left (A) and the inanimate on the right (B), and on the other half this was reversed.

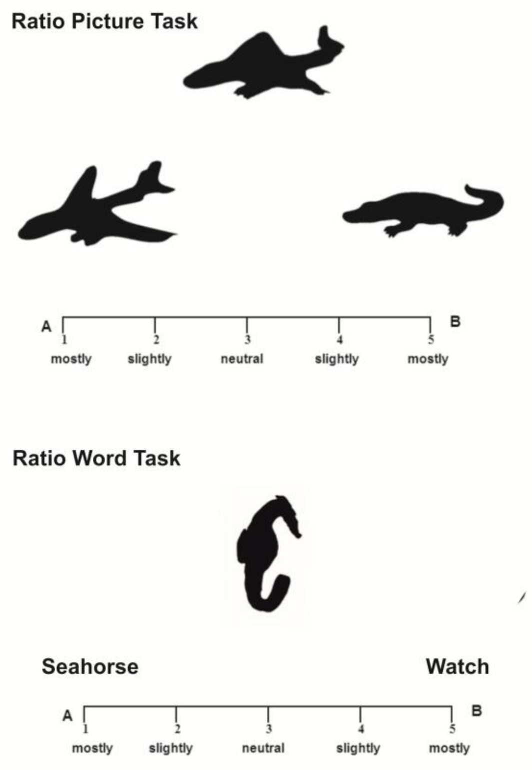

Figure 2.10. Ratio Picture Task (top), ambiguous object A consists of 50% B1 and 50% B2. Participant is asked to rate on a scale from 1-5 whether object A is more similar to object B1 or object B2. The Ratio Word Task (bottom), Ratio Picture Task (top), ambiguous object A consists of 50% B1 and 50% B2. Participant is asked to rate on a scale from 1-5 whether object A is more similar to the object indicated by word B1 or by word B2.

CHAPTER 3. (Re-)conceptualisation of Silhouette Objects in Asperger's Syndrome and Typical Individuals with Varying Degrees of Autistic-like Traits

Abstract

The abilities to form new concepts from scratch (conceptualisation), and to flexibly switch from one concept to another (reconceptualisation), were investigated in adults with Asperger's Syndrome (AS) and in typically-developed adults with low and high autism quotients (AQ). In consecutively presented morphs, containing increasing percentages of animate or inanimate objects, the emerging objects had to be identified. The results suggest that the abilities to conceptualise and to reconceptualise become increasingly impaired with increasing autistic(-like) traits. Across both tasks, all groups recognised animate objects quicker than inanimate objects. However, this 'animate advantage' was differently affected by the two tasks. In the Reconceptualisation task, the animate advantage gradually disappeared with increasing autistic(-like) traits, whereas in the Conceptualisation task it remained present. On both tasks, the results of the High AQ group occupied an intermediate position between those of the Low AQ group and the AS group.

Introduction

The ability to rapidly and accurately trade in one concept for another is crucial for successful social interactions, as the mental states and intentions in social exchanges may change rapidly and at any time. There is growing scientific evidence that deficiencies in these executive abilities may underlie some of the core problems in autism spectrum disorders (ASD).

Various theories about the underlying mechanisms that may cause the social and cognitive deficits in ASD have been put forward (e.g. Frith, 2001). It has been argued that the impairment in social cognition found in ASD reflects a difficulty to form a Theory of Mind

(ToM), i.e. to read the behaviour of others (and of oneself) in terms of epistemic mental states (e.g. desires and beliefs; Frith, Morton & Leslie, 1991; Baron-Cohen, 1995), and to empathize with others (Baron-Cohen, 2005). It is argued that the ToM hypothesis concentrates mainly on the social deficits in ASD, without taking into account other domains such as language, imagination and motor behaviour (Volkmar et al., 2004). It is also argued that a deficiency in perceptual integration in complex social situations prevents individuals with ASD from using their intact ToM (Verbeke et al., 2005).

Other theories are the Central Coherence theory, which postulates a preference for local over global processing (e.g. Happé & Frith, 2006) and the Executive Functioning theory (e.g. Russell, 1998), which argues that deficits in executive functions such as response inhibition (Hill & Bird, 2006), planning (Ozonoff & Jensen, 1999), cognitive flexibility (Geurts et al., 2004) and concept switching (Delis, Kaplan & Kramer, 2001) could underlie many of the cognitive problems in autism *(see Chapter).* In the current study we investigated possible deficits in AS with respect to the executive function of concept switching.

Concept Forming and Concept Switching

As described in the previously *(see Chapter 1),* concept forming and object identification are largely interchangeable. However, for the purpose of these tasks we use the term 'concept forming' as referring to the ability to form new concepts from scratch, and the term 'concept switching' as referring to the ability to flexibly switch from one concept to another involving disengagement of attention from a concept held in mind. The aim of this chapter is to investigate concept forming and concept switching as two distinct executive functions, as most previous literature has not attempted to disassociate them, particularly on tasks were multiple stimuli is presented simultaneously (e.g. Delis et al., 2001).

Most previous research has concentrated predominantly on individuals with low-functioning ASD. The general consensus is that this group exhibits problems in disengaging attention (i.e. Hughes & Russell, 1993; Swettenham et al., 1998; Landry & Bryson, 2004;

Kaland, Smith & Mortensen, 2008). However, it is our aim to investigate whether individuals with HFA or AS have similar deficiencies, nor is it known whether the deficiency extends into the typically-developed (TD) population.

The Distinction between Animate and Inanimate Objects in ASD

TD individuals rely heavily on non-verbal bodily cues, such as gaze direction, facial expressions and postures, to evaluate the social communicative intentions of others (e.g. Allison, Pruce & McCarthy, 2000; Blakemore & Decety, 2001). There is some evidence that individuals with ASD are specifically compromised in processing social cues derived from animate objects (Dawson & Fernald, 1987; Baron-Cohen & Swettenham, 1997; Deruelle, et al., 2004), especially when processing these cues spontaneously or involuntary (Jellema et al., 2009; Senju et al., 2009). Children with ASD have been described to be generally more interested in inanimate than animate objects (Hobson, 1987; Swettenham et al., 1998; Cipolotti et al., 1999; Blair et al., 2001). They have been found to be better at discriminating between pictures of buildings than of people (Boucher & Lewis, 1992; Boucher, Lewis & Collins, 1998), to be compromised in discriminating between male and female, and between child and adult (Charman et al., 1997), to recall mechanical events better than non-social events (Bowler & Thommen, 2000), and to show a deficit in categorising objects as animate on the basis of their motion (Rutherford, Pennington & Rogers, 2006).

The Autism-Spectrum Continuum

Autistic characteristics have been proposed to extend into the TD population as ‘autistic-like’ features (Baron-Cohen et al., 2001). The basic assumption is that autism reflects a continuum underlying the entire population *(see Chapter 2)*. An individual’s position on this underlying autism continuum can be assessed with the autism-spectrum quotient (AQ) questionnaire, measuring the extent to which that individual possesses autistic-like traits

(Baron-Cohen et al. 2001; Baron-Cohen, 2002) and a TD sample to be divided into subgroups (Bayliss & Tipper, 2005).

The Current Study

We tested the ability to form new concepts, and the ability to flexibly switch from one concept to another, in TD adults with high and low AQ scores, and in adults with AS. A first aim was to determine whether these two abilities are distinct and can be differentiated. If a group is poor in reconceptualisation, would they then also have to be poor in conceptualisation? Or does a deficit only emerge when one has to disengage from a concept, while conceptualisation *per se* may be intact?

The second aim was to find out whether an impairment in one or both of these abilities applies equally well to all categories of objects, or whether there are categories that are more susceptible than others. We contrasted animate and inanimate objects, as there is ample anecdotal, and growing scientific, evidence that individuals with ASD are impaired in processing animate objects as compared to inanimate objects. A third aim was to investigate if deficiencies in the ability to form concepts, and/or switch between them, forms a continuum underlying the entire population. If so then one would expect the low AQ group to perform best, followed by the high AQ group, followed by the AS group. Such a finding would support the notion that typical ASD features can be found in the entire population in varying degrees. There are indications that the ability to switch between concepts indeed differs widely in the TD population (Verstijnen & Wagemans, 2004).

Method

Participants

Clinical Group

The clinical group consisted of twenty-three students recruited through disability services at universities in the North-East of England (UK). All these students had previously received a diagnosis of AS or HFA based on DSM-IV criteria (APA, 2000). Evidence of prior psychological reports, containing a conclusive diagnosis of ASD, was acquired. In the period in which the current experiments were conducted, the ADOS (Autism Diagnostic Observation Schedule, module 4, *see Chapter 2*) was administered to all participants in the clinical group *(see Table 3.1).* Three participants were excluded for having ADOS scores lower than 7 (scores of 4, 5 and 6). Prior records and current examinations indicated that all students met the criteria for AS, as there was no evidence of language delay, while all participants had a cognitive ability within the average range or above without associated learning disabilities.

The twenty remaining participants that were included in the analysis (15 males, 5 females; mean age = 21.2 years, SD = 6.1) had a mean total ADOS score of 8.0 (SD = 0.92), a mean IQ score of 117 (SD = 9.8; assessed using the Wechsler Adult Intelligence Scale, WAIS-III, Wechsler, 1997), and a mean AQ score of 31.1 (SD = 8.6) (*see Table 3.1* for sub-scores).

Group	*n*	Age	Sex	AQ	IQ-T	IQ-V	IQ-P	ADOS
ASD	20	21.2 (6.1)	5 F, 15 M	31.1 (8.6)	117.2 (9.8)	119.1 (13.7)	112.2 (14.5)	8.0 (0.9)
Low AQ	22	21.3 (3.6)	9 F, 13 M	8.9 (1.7)	112.5 (9.4)	115.5 (8.2)	109.8 (12.0)	
High AQ	23	20.7 (3.3)	10 F, 13 M	25.2 (4.9)	116.1 (9.9)	115.8 (9.3)	114.7 (13.2)	

Table 3.1. Participant characteristics. Age is in years. Standard errors are shown between brackets. F, female; M, male; AQ, Autism-spectrum Quotient; IQ-T, total IQ score; IQ-P, Performance IQ score; IQ-V, verbal IQ score.

Typically developed group

One hundred and two students from the Hull University were recruited from a range of departments in the Arts, Natural sciences, Humanities and Social sciences. Prior to the experiment, participants completed an online version of the AQ (Baron-Cohen et al., 2001, *see Chapter 2*). After ranking all participants on the basis of their AQ scores (mean = 16.1, SD = 6.3), the upper and lower 20% (approximately) were selected, so that the group sizes were similar to that of the AS group. The low AQ group consisted of 22 participants (9 females, 13 males), mean age = 21.3 years (SD = 3.6), with a mean AQ score of 8.9 (SD = 1.7, range 5 to 11). The high AQ group consisted of 23 participants (10 females, 13 males), mean age = 20.7 years (SD = 3.3), with a mean AQ score of 25.2 (SD = 4.9, range 21 - 35). The male/female ratios in the low AQ, high AQ and AS groups did not differ from each other (all p's > .18). The IQ (WAIS III, Wechsler, 1997) was determined for 15 participants of the low AQ group (M = 112.5, SD = 9.4) and for 14 of the high AQ group (M = 116.1, SD = 9.9), which scores did not differ from each other, nor from those of the AS group (all p's > .16). Because of their academic qualifications, and the absence of any learning difficulties, it was assumed that both groups of TD students would have an IQ within the average range or above, which was confirmed by the IQ tests performed on the group samples.

All TD and AS participants had normal or corrected-to-normal vision, and provided written consent prior to the experiment. Participants received course credits or a fee for taking part. The study was approved by the Ethics committee of the host research institution.

Stimuli

For both tasks objects were selected from a large set of contour drawings (based on line drawings by Snodgrass & Van der Wart, 1980) of a wide range of animate and inanimate objects for which normative identification rates had been established (De Winter & Wagemans, 2004). In addition, human figures in different orientations were selected from a stimulus set by Downing et al (2004). Morphs (interpolations) between pairs of objects were made using Sqirlz-Morph software (Xiberpix, Shirley, Solihull, UK). Morphed sequences were made between animate objects, inanimate objects, and animate and inanimate objects. Each morphed sequence consisted of 20 interpolations (5% change; see Figure 3.1). All contour drawings (the original and interpolated ones) were filled with black, resulting in silhouettes. The stimuli were presented in the center of a computer screen (maximum on screen height was 10 cm and maximum width was 14 cm), against a white background *(see Figure 3.1)*

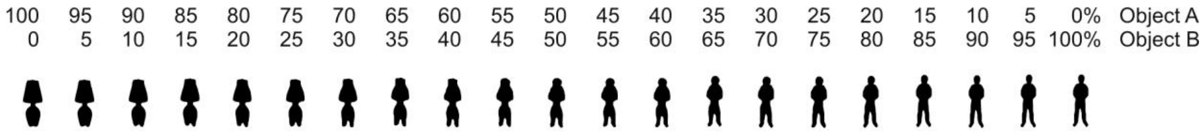

Figure. 3.1. *Example of a morphed sequence of a lamp (far left) and a man (far right) in steps of 5% change. Note that the object midway the sequence, consisting of 50% lamp and 50% man, cannot be identified as either of them without prior knowledge of the end-objects.*

Differences in the geometrical complexity of the silhouettes of animate versus inanimate objects, could in principle affect the recognition scores for these two categories. We therefore qualified the complexity of the silhouettes using two measures: compactness and homogeneity. Compactness is defined as (length contour line)/(surface area)^2. Homogeneity is defined as (length contour line)/(number of peaks)^2, where the number of peaks is based on an adaptive smoothing algorithm (Horng, 2003). Thus silhouettes with fewer peaks have higher homogeneity values. For both tasks, the silhouettes of animate and inanimate objects did not differ from each other in compactness or homogeneity (Conceptualisation Task: compactness, $t(23) = -.16$, $p = .88$, two-tailed; homogeneity, $t(23) = -1.16$, $p = .28$; Reconceptualisation task: compactness, $t(22) = -.28$, $p = .78$; homogeneity, $t(22) = -1.72$, $p = .099$).

Two different sets of 28 objects (14 animate and 14 inanimate) were used in the two tasks. These two sets of 28 objects did not differ from each other in terms of Compactness (t(47) = 1.2, *p* = .23) or homogeneity (t(47) = 0.69, *p* = .50).

Further, the 14 animate objects in set 1 were matched to the 14 animate objects in set 2, and the same for the inanimate objects in both sets, on 8 different variables *(see Table 3.3).* These variables again included Compactness and Homogeneity, and further included Name agreement, Image agreement and Familiarity. The latter three were derived from Snodgrass and Vanderwart (1980), and were based on line-drawings of the objects. A fourth variable provided by Snodgrass and Vanderwart (1980), Visual complexity, was not relevant as it referred to the detail and intricacy of lines within the line-drawing (we exclusively used silhouette objects). We also used Kučera-Francis frequency counts for single-word object names (Kučera & Francis, 1967), which were provided by Snodgrass and Vanderwart (1980). Finally, we used identification rates (i.e. counts for both the exact object name and for the correct concept) for silhouette representations of the line-drawings provided by De Winter and Wagemans (2004). The silhouettes used by De Winter and Wagemans (2004) were identical to the ones used in the current study. The sets of animate objects employed in both tasks did not differ significantly on any of these 8 measures, nor did the sets of inanimate objects differ on any of these measures *(see Table 3.2* for details).

	Inanimate objects		Animate objects	
	t	*p*	*t*	*p*
Compactness	1.24	.22	1.3	.20
Homogeneity	.69	.50	1.8	.09
Name agreement *[1]*	1.1	.28	.03	.98
Image agreement *[1]*	.09	.93	.32	.75
Familiarity *[1]*	.13	.90	1.7	.10
Word frequency counts *[2]*	.16	.88	.76	.45
Identification - exact name *[3]*	.06	.95	1.3	.19
Identification - correct concept *[3]*	.89	.38	.67	.51

Table 3.2. Comparisons of the 14 inanimate objects in the Conceptualisation Task with the 14 inanimate objects in the Reconceptualisation tasks (Inanimate objects), and of the 14 animate objects in the Conceptualisation Task with the 14 animate objects in the Reconceptualisation Tasks (Animate objects), are shown for eight different object variables (left column). The t and p values are shown. [1] Snodgrass and Vanderwart (1980); [2] Kučera and Francis, 1967; [3] De Winter and Wagemans (2004).

Procedure

Directly prior to the experiment, all participants completed an online version of the AQ questionnaire (duration 5 minutes). Participants were then seated in front of a 21 inch PC monitor at a distance of 1 m, and instructed to sit back and relax throughout the experiment. All instructions and visual stimuli were presented on screen (E-prime, Psychology Software Tools Inc., Sharpsburg, USA; 600 x 800 resolution). First, four practise trials were given, the experimenter then verified the participant's understanding of the task, after which the experiment began. The exact duration of the experiment depended on the participant's performance, but lasted on average 12 minutes. Participants were told they could make unlimited verbal guesses as to what they thought the object was morphing into. The experimenter recorded all guesses made by the participant and the frame number at which the correct answer was given. All participants performed two tasks, a Conceptualisation Task and a Re-Conceptualisation Task *(Figure 3.2).*

Task 1: Conceptualisation

The morphing sequence started with an unidentifiable object consisting of 50% object A and 50% object B, i.e. midway of full sequence. For the participant, this object had an arbitrary form (resembling an ink blob). The object then morphed into object B (i.e. the contribution of object A gradually decreased and that of object B gradually increased). Each picture was presented for 3 s and was then immediately followed by the next one (ISI = 0 ms). In this task the participant thus started off without a concept in mind. The number of interpolations needed to give the correct answer was recorded, as were all incorrect guesses.

Task 2: Re-conceptualisation

The morphing sequence started with 100% object A (0% object B). The participant was asked to name this object (which was successfully done in all cases), so as to ensure that this concept was in the participant's mind at the start of the sequence. As the sequence developed, the contribution of object A gradually decreased and that of object B gradually increased until 100% object B (and 0% object A) was reached. The first 10 pictures were shown in a rapid succession of 1 frame per second. Starting from frame 11 (50% A/50% B), the participants were allowed to make guesses and the pictures were shown at a rate of 3 per second. Again, the number of interpolations needed to correctly name the emerging object plus all incorrect guesses, were recorded. In this paradigm the participant thus started off with a specific concept in mind, and a reconceptualisation needed to take place. In other words, concept A had to be traded in for concept B. It should be noted that the Reconceptualisation task did not involve perceptual hysteresis, which is the persistence of a percept despite parameter change to values favouring an alternative pattern (Hock, Kelso & Schoner, 1993). The 50% A/50% B object midway the sequence did not look like object A anymore. In fact, in the Conceptualisation task, which started with the 50% A/50% B object, none of the participants made a correct guess for this object (neither A or B). And certainly further along the sequence (e.g. 65%A/35%B) the percept of the object in nothing resembled that of the 100% object object A. The persistence of object A was therefore purely mental, i.e. the persistence of the concept of object A, not the persistence of a percept as described by Hock et al. (1993) for hysteresis.

The start and end objects were counterbalanced across participants. To be able to directly compare the scores on the two tasks, we subtracted the value 10 from the scores in the Reconceptualisation Task (frame 11 in the Reconceptualisation task was equivalent to frame 1 in the Conceptualisation Task, both containing 50% of object A and 50% of object B; *see Figure 3.2).*

It should be noted that although we tend to use ‘concept formation’ and ‘object identification’ interchangeably, the two are not exactly the same. A concept refers to a mental representation that summarises the relations and structures among members of a category on the basis of a principle or rule, and does not discriminate between different members of the same category (Johnson & Ratkinson, 2006). Given that all information provided about the endobject by the morphed stimuli is contained in the contour line (the interior is filled with black), it is virtually impossible for a participant to identify the individual member of the object category. Therefore, the current tasks measure concept formation rather than object identification. For example, a morph of a cow and a chair looks neither like a cow or a chair until towards either end of the sequence. The participant is forced to compare and contrast the previously learned relations and structures of a wide range of concepts with the presented morphed stimulus in order to form a new concept. Thus, when the participant gives the correct response (“cow”) to a certain interpolation on the chair-to-cow dimension, it is not because the object has the correct ‘cow’ shape, but because the shape properties start to resemble those that are included in the ‘cow’ concept.

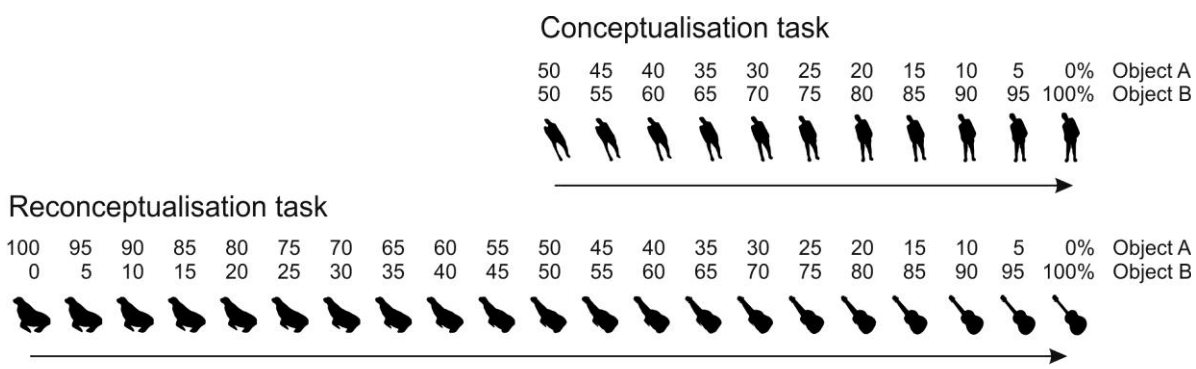

Figure 3.2. Schematic representation of the Conceptualisation and Reconceptualisation tasks. The Conceptualisation Task started with an unidentifiable morphed object consisting of 50% of object A and 50% of object B, and ended in 100% object B. The Reconceptualisation Task started with 100% object A, and ended in 100% object B.

Results

As our theoretical assumption was that the two tasks measure different abilities (to conceptualise versus to reconceptualise) we started off with an overall 2x2x3 repeated measures ANOVA, in which the within-subject factors were Task (Conceptualisation vs. Reconceptualisation) and Endobject (animate vs. inanimate), and the between-subjects factor was Group (low AQ vs. High AQ vs. AS). This analysis showed a significant main effect for Task ($F(1, 62) = 33.2$, $p < .001$, $\eta_p^2 = .35$), reflecting that the number of frames required to correctly identify the objects was higher in the Conceptualisation task (M = 5.0, SD = 1.1) than in the Reconceptualisation task (M = 4.6, SD = 1.2). The main effect of End-object was highly significant ($F(1, 62) = 126.3$, $p < .001$, $\eta_p^2 = .67$), reflecting that the images of animate objects were easier to identify than those of inanimate objects, on average 4.3 (SD = 1.2) images were required for the animate objects and 5.2 (SD = 0.9) images for the inanimate objects. This advantage for animate objects could have been due either to the animate objects being inherently easier to recognise (possibly more familiar) than the inanimate ones, or to an underlying ‘processing benefit’ for animate objects. The main effect for Group was significant ($F(2, 62) = 13.5$, $p < .001$, $\eta_p^2 = .30$).

Of the two-way interactions, the Task by Group interaction was not significant ($F(2, 62) = 2.1$, $p = .13$, $\eta_p^2 = .065$), the Endobject by Group interaction was significant ($F(2, 62) = 10.9$, $p < .001$, $\eta_p^2 = .26$) and the Task by Endobject interaction was significant ($F(2, 62) = 10.3$, $p = .002$, $\eta_p^2 = .14$). The 3-way interaction was significant ($F(2, 62) = 3.2$, $p = .048$, $\eta_p^2 = .093$). We next performed two-way (Endobject by Group) analyses for each task separately (Bonferroni corrected $\alpha = .017$).

Conceptualisation Task

The main effect of Endobject was significant ($F(1, 62) = 116.7$, $p < .001$, $\eta_p^2 = .65$), reflecting that the images of animate objects (M = 4.4, SD = 1.1) were easier to identify than those of inanimate objects (M = 5.5, SD = 0.8). The main effect of Group was also significant (*F*(2, 62) = 12.3, $p < .001$, $\eta_p^2 = .28$). The AS group (M = 5.5, SD = 0.8) required significantly more frames than the Low AQ group (M = 4.4, SD = 1.0) (*t*(40) = 5.7, $p < .001$), but not significantly more than the High AQ group (M = 5.1, SD = 1.2) (*t*(41) = 1.8, $p = .082$), although this difference approached significance. The High AQ group required significantly more frames than the Low AQ group (*t*(43) = 3.0, $p = .004$). The Endobject by Group interaction factor was non-significant (*F*(2, 62) = 2.6, $p = .081$, $\eta_p^2 = .078$), indicating that the animate advantage (defined as the number of frames required to identify inanimate objects minus the number of frames required to identify animate objects) was similar for the three groups. The mean 'animate advantage' for the Low AQ group was 1.3 frames, for the High AQ group 1.1 frames, and for the AS group 0.6 frames.

Reconceptualisation task

Similar to the Conceptualisation task, the main effect of Endobject was significant (*F*(1, 62) = 50.3, $p < .001$, $\eta_p^2 = .45$), reflecting that the images of animate objects (M = 4.2, SD = 1.2) were easier to identify than those of inanimate objects (M = 4.9, SD = 0.8). The main effect of Group was also significant (*F*(2, 62) = 11.9, $p < .001$, $\eta_p^2 = .28$). The AS group (M = 5.3, SD = 1.0) required significantly more frames than the Low AQ group (M = 4.4, SD = 1.0) (*t*(40) = 5.1, $p < .001$), and also significantly more frames than the High AQ group (M = 4.5, SD = 1.1) (*t*(41) = 2.9, $p = .006$). The difference between the High and Low AQ groups approached significance (*t*(43) = 2.0, $p = .047$). Importantly, in stark contrast to the Conceptualisation task, the Endobject by Group interaction factor was significant (*F*(2, 62) = 13.8, $p < .001$, $\eta_p^2 = .31$), indicating that in the Reconceptualisation task the animate advantage was no longer similar for the three groups. The animate advantage for the Low AQ group (M = 1.3, SD = .7) was significantly larger than the (very small) animate advantage for the AS group (M = .06, SD = 0.5) (*t*(40) = 6.4, $p < .001$) and was also larger than that of the High AQ group (M = 0.7, SD = 0.9) (*t*(43) = 2.6, $p = .012$). The animate advantage for the High AQ group was also significantly larger than that of the AS group ($t(41) = 2.5$, p = .019).

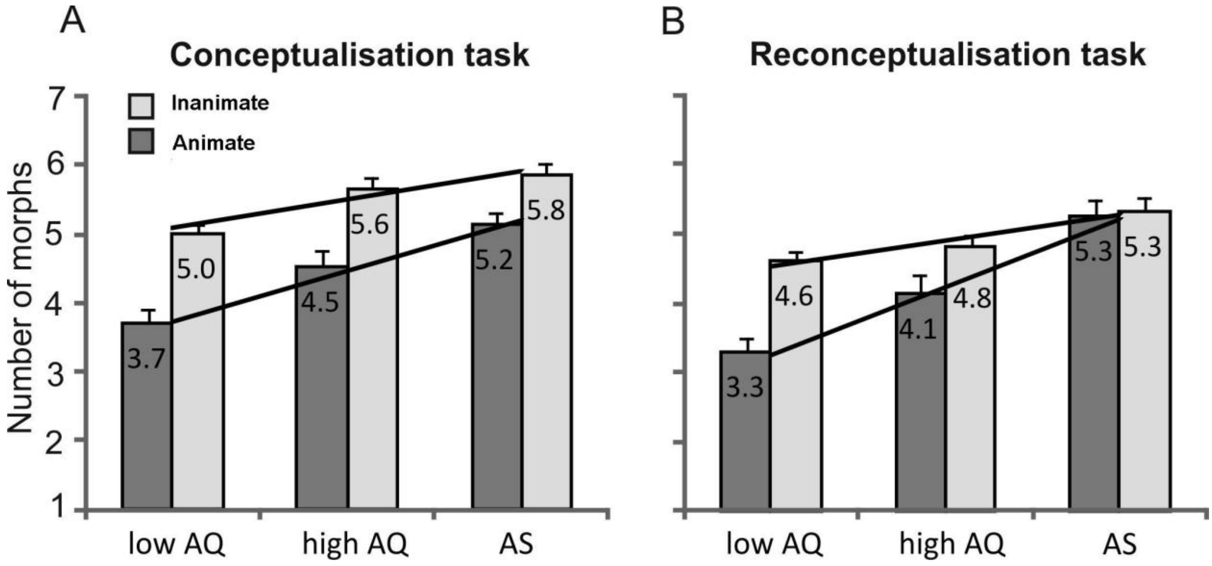

Figure 3.3. The results on the Conceptualisation Task (A) and Reconceptualisation Task (B). A-B, The mean number of images required to correctly identify the object is shown for the three participant groups: the low AQ, high AQ and AS groups. Linear trend lines are only shown for illustrative purposes as the groups are on an ordinal scale. Error bars indicate standard errors.

In the Reconceptualisation Task, we further looked whether there was an interaction between the animate or inanimate nature of the start- and endobjects. In other words, was the recognition of the endobject influenced by the presence of a category shift between start and endobject (i.e. from animate to inanimate or vice versa)? A 2x2x3 ANOVA in which the within-subject factors were the Start- and End-object (both animate or inanimate), while Group (low AQ, high AQ, AS) was the between-subjects factor, revealed no significant 2 or 3 way interactions (3-way interaction Start-object x End-object x Group: $F(2, 62) = 1.3$, $p = .22$, $\eta_p^2 = .047$).

Correlations with AQ

The correlations between the AQ scores of all 65 participants and the extent in which they showed an ‘animate advantage’ (defined as the number of frames required to identify inanimate objects minus the number of frames required to identify animate objects) supported the above findings. The correlation was non-significant in the Conceptualisation Task (Pearson, two-tailed, r = -.202, p = .106), but highly significant in the Reconceptualisation Task (r = -.45, p < .001).

Incorrect Guesses

All incorrect guesses made by all participants on both tasks were recorded to be able to determine whether any differences existed between the three participant groups in absolute number of guesses made, and/or differences in the relative numbers of animate and inanimate guesses.

Conceptualisation Task

The mean number of guesses made before the correct answer was given (the correct answer was given in all cases) was 0.68 in the low AQ group, 0.53 in the high AQ group and 0.33 in the AS group *(see Figure. 3.4a)*. The AS group made significantly less guesses than the low AQ group (t(39) = 4.7, p < .001), but did not differ from the high AQ group (t(40) = 2.2, p = .036, Bonferroni corrected α = .017), nor did the low and high AQ groups differ from each other (t(43) = 1.6, p = .13).

All guesses were classified as either animate or inanimate. In the low AQ group, 62.1% of the incorrect guesses were animate, in the high AQ group 63.8% were animate, and in the AS group 75.2%. In all 3 groups animate responses were given significantly more often than inanimate responses (all p’s <.001).

Reconceptualisation Task

The mean number of guesses (before the correct one was given) was .34 in the low AQ group, .25 in the high AQ group and .22 in the AS group. The 3 groups did not differ from each other in number of guesses (all *p*'s > .13).

In the low AQ group 70.2% of guesses were animate, in the high AQ group 61.7% and in the AS group 70.9%. In the low AQ and AS groups significantly more animate than inanimate guesses were made (*p*'s < .005), while it just did not reach significance in the high AQ group ($p = .020$, $\alpha = .017$). When comparing the number of guesses on the two tasks, for the both low and high AQ groups the numbers of guesses were significantly lower than in the Conceptualisation Task (*p*'s < .001). For the AS group the reduction in number of guesses just did not reach significance after Bonferroni correction ($p = .020$, $\alpha = .017$).

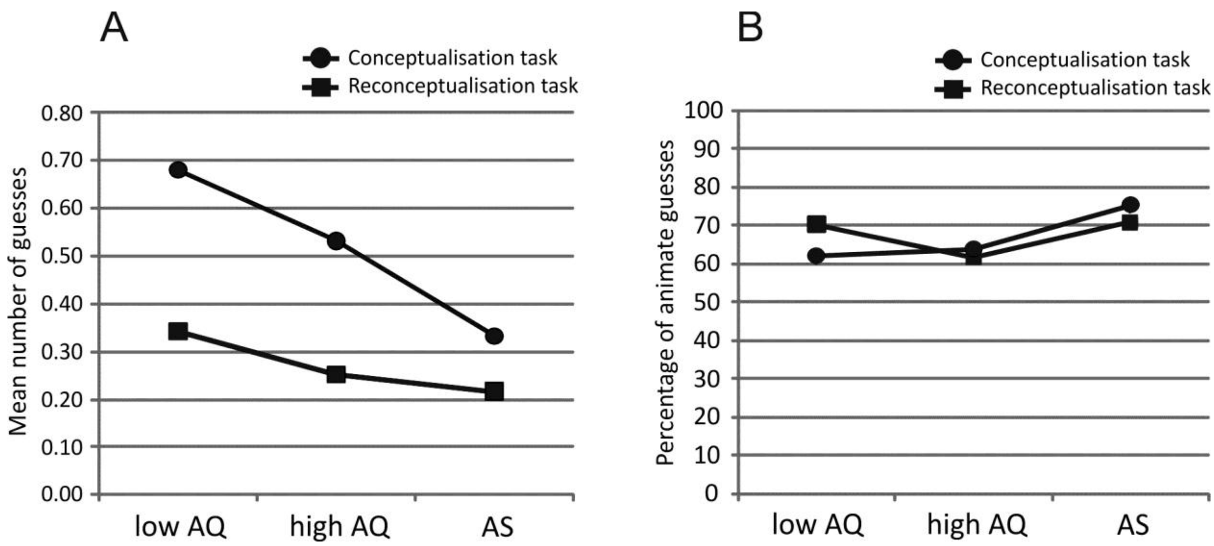

Figure. 3.4. Guesses made before the correct response was given. (A) Mean number of total guesses (animate and inanimate) made by the three groups in the Conceptualisation and Reconceptualisation Tasks. (B) The percentages of animate guesses are shown.

IQ

To rule out intelligence as a potential variable, an analysis of covariance (ANCOVA) was performed between Groups (TD vs. AS), Endobject (Animate vs Inanimate) and IQ (Verbal and Perceptual). In the Conceptualisation Task, no significant difference was found between endobject and verbal ($F(1, 43) = .951$, $p = .335$, $\eta_p^2 = .000$) or perceptual ($F(1, 43) = 688$, $p = .411$, $\eta_p^2 = .016$) intelligence. Similarly, in the Reconceptualisation Task, no significant difference was found between endobject and verbal ($F(1, 43) = .005$, $p = .944$, $\eta_p^2 = .000$) or perceptual ($F(1, 43) = .346$, $p = .560$, $\eta_p^2 = .008$)

Discussion

We examined whether the ability to form new concepts from scratch (experiment 1: Conceptualisation Task), and the ability to flexibly switch from one concept to another involving disengagement from a concept (experiment 2: Reconceptualisation Task) were differently affected in individuals with AS, and in TD individuals with either high or low scores on the AQ. These three groups can be thought of as occupying successive positions on an ASD dimension, with the low AQ group having fewest, and the AS group having most, autistic(-like) traits (Baron-Cohen et al., 2001; Baron-Cohen, 2002). We further examined whether the nature of the objects that had to be recognised (animate vs. inanimate) affected the conceptualisation and reconceptualisation abilities.

The results indicated that in the Conceptualisation Task more frames were required to correctly identify the objects than in the Reconceptualisation Task. At first this may seem surprising as concept switching should, if anything, hamper the identification of the end-objects in the Reconceptualisation task. However, the Reconceptualisation task did not only differ from the Conceptualisation task with respect to the switching requirement, it also differed in that the build-up of object B started already from 5% (95%A/5%B object), whereas in the Conceptualisation task the build-up started at 50%. Thus information about the to-be-identified endobject was already present early on in the sequence. In the Conceptualisation task, the 50%A/50%B object (frame 1) looked like an ink blob and no participants made a correct guess at this stage (neither identifying object A or object B).

However, in the Reconceptualisation task, in a few cases correct guesses of object B were already made at the 50%A/50%B stage (frame 11; participants were not allowed to respond during the first 10 frames up to 50%A/50%B, which 10 frames were shown in rapid succession of 1 frame per second). This suggests that in the Reconceptualisation task the build-up of dynamic information about the endobject during the first half of the sequence facilitated the identification of the endobject. Thus the Reconceptualisation task differed from the Conceptualisation with respect to at least two factors, one of which might have facilitated identification of object B (prolonged build-up of information) and one might have impaired identification (requirement to switch concepts). At present we cannot yet discriminate between these two factors. Future experiments will have to address this. However, it does not take anything away from the finding that the recognition of the animate and inanimate objects was differently affected by the two tasks.

Overall, images of animate objects were identified quicker than those of inanimate objects. This might reflect a greater familiarity of the animate objects as compared to the inanimate objects, or might be due to the animate objects possessing more characteristic features, which helped their identification. However, the compactness and homogeneity scores did not differ between animate and inanimate objects, indicating that the two categories were equally complex in terms of their shapes. Alternatively, it could be due to an underlying processing benefit for animate objects.

The results convincingly showed that both the abilities to conceptualise and to reconceptualise become increasingly impaired with increasing autistic(-like) traits. The AS group needed more frames (approaching significance) than the high AQ group, who required significantly more frames than the low AQ group. The significant difference between the low and high AQ groups on both tasks was quite remarkable as both groups consisted of TD individuals, that did not differ significantly in terms of sex, age or IQ. Differences between low and high AQ groups have been reported before on gaze and symbolic cuing tasks (e.g. Baylis & Tipper, 2005; Baylis et al., 2005), but had not yet been reported for object recognition. The findings are in line with the theory that ASD features can be found in the entire population in varying degrees (cf. Baron-Cohen, 2002). This notion was further corroborated by the correlation analysis.Importantly, the ‘animate advantage’ (i.e. the number of frames needed to identify inanimate objects minus the number of frames needed to identify animate objects) was not evenly distributed across the three groups and two tasks, but showed a distinct and specific distribution. That is, in the Conceptualisation Task the ‘animate advantage’ remained fairly constant across the three groups (reflected by the absence of an endobject by group interaction effect), whereas in the Reconceptualisation Task the ‘animate advantage’ significantly reduced with increasing autistic(-like) traits. In the latter task, the ‘animate advantage’ had disappeared altogether in the AS group, while in the Conceptualisation Task the AS group showed a significant ‘animate advantage’.

The ‘Animate Advantage’ in the AS Group

Why would the AS group have lost the ‘animate advantage’ in the Reconceptualisation Task, but not in the Conceptualisation Task? One possibility is that the additional requirement to switch between concepts led to a reduction in attentional resources available to identify the endobject, as attentional resources may still have been partly attached to the first object. Disengaging attention from an object has been reported to be compromised in low-functioning ASD (Hughes & Russell, 1993; Swettenham et al., 1998; Landry & Bryson, 2004). Thus, when full attentional resources are allocated to the new object (as in the Conceptualisation Task), the AS group shows an ‘animate advantage’ similar to the TD groups, but when less resources are available the problem becomes exposed.

We propose that the reduced ‘animate advantage’ of the AS group was due to an impaired ability to process and identify animate objects, which became exposed in the Reconceptualisaton Task due to the additional requirement of having to switch between concepts. However, a number of alternative explanations could be envisaged and their merits will be discussed first.

(i) In individuals with ASD the concepts of animate objects don't spring to mind as easily as those of inanimate objects, and therefore chances of guessing correctly are smaller when the endobject is animate. The study of the incorrect guesses, however, indicated that the problem does not seem to be related to the generation of animate versus inanimate guesses, as very similar percentages were obtained for each group. If anything, the animate/inanimate ratio was higher in the AS group than in the TD groups.

(ii) The animate shapes were more complex then the inanimate ones, which, under conditions of reduced attentional resources (i.e. Reconceptualisation Task) resulted in poorer recognition of animate objects. This seems unlikely as the analysis of the homogeneity and compactness scores suggested that the two categories did not differ in shape complexity.

(iii) A deficit in establishing general abstract categories selectively disadvantaged the recognition of animate objects. Individuals with ASD may have difficulties with establishing the general category to which a specific object belongs, especially when the objects belonging to a particular category differ widely in shape and appearance. A good example is the category of dogs (Grandin, 1995). If the abstract concept of a dog is lacking, then, in order to identify a newly encountered breed of dog as a dog, the memory for already established examples of dog breeds needs to be deliberately updated with the new breed. However, most animate subclasses that were used (e.g. butterfly, chicken, penguin) do not come in such big varieties as dogs. Moreover, the inanimate objects that were used also come in large varieties (e.g. sofa, lamp, and hat). We therefore think it unlikely that a deficit in establishing general abstract categories could have selectively disadvantaged the recognition of animate objects.

(iv) An impairment in feature integration in ASD (Happé & Frith, 2006) specifically hampered the recognition of animate objects. This might be the case if the identification of animate objects requires more feature integration then that of inanimate objects. Such a scenario might occur if there are more plausible alternatives to animate objects then to inanimate objects. A dog at 70% might indeed be mistaken for a cat, a cow, a horse, a deer etc. The recognition of animate objects may thus require a larger degree of differentiation between possible alternatives, and therefore a larger degree of feature integration, in order to correctly identify the object. However, the shape of other animals that were used quite uniquely identified them (e.g. butterfly, chicken). Moreover, if there were indeed more plausible alternatives to animate objects then to inanimate objects, then one would expect an increase in animate guesses relative to inanimate guesses, but that was not found. It is therefore hard to imagine that impaired feature integration can explain the disappearance of the ‘animate advantage’ in the AS group.

Processing Deficit for Animate Objects

A processing deficit for animate objects in AS could be related to deficiencies in the so called ‘social brain’ (Brothers, 1990; Dunbar, 1998; Adolphs, 1999; Allison et al., 2000). Several studies have found reduced activity in areas of the brain associated with processing social or animate objects in autistic individuals (Baron-Cohen et al., 2001; Castelli et al., 2002; Dapretto et al., 2006). Behavioural impairments in social cognition and social perception are typically found in developmental disorders, most notably in ASD (Frith & Frith, 1999; Jellema et al. 2009) and Schizophrenia (Van ‘t et al., 2010). Also, single neuron recordings (e.g. Jellema & Perrett, 2002), human lesion studies (e.g. Warrington & Shallice, 1984) and imaging studies (e.g. Beauchamp et al., 2002; Wheatly, Milleville & Martin, 2007; Fuggetta et al., 2009) have all highlighted the dissociation between the representations for animate and inanimate objects, by showing that they activate distinct and different cortical areas. A deficit in processing animate objects, surfacing in particular when switching is required and attentional resources are reduced (Reconceptualisation Task), might underlie the progressive impairment in the recognition of animate but not inanimate objects, with increasing autistic traits.

Impaired concept forming and switching found in individuals with AS in the current study, especially with respect to animate objects, may help to explain the deficits individuals with ASD have in social interactions, i.e. keeping up with the pace of social exchanges. Although, the nature of the stimuli used in these studies is silhouette morphs of animate and inanimate objects and it would be unjustified to use to findings to explain social understanding (i.e low-level mindreading), the studies required the individual to form - and switch between - concepts rapidly, as does social interaction (i.e. reading another individual's mental states, intentions and feelings as they change rapidly). Moreover, in addition to an immediate and involuntary understanding (i.e. low-level mindreading, cf. Goldman, 2006), social understanding often involves some sort of hypothesis testing: one forms an idea about e.g. the other's intention and then tests this idea, i.e. one looks for further evidence that will either corroborate or falsify it, requiring flexibility in reconceptualisation. The implications are discussed further in the general discussion (*see Chapter 9).*

Summary

In summary, the first aim of the current study was to determine whether the abilities for conceptualisation and reconceptualisation can be differentiated. The current results do not indicate that the tasks affected the groups differently; the overall response patterns obtained in the two tasks were quite similar (no significant Task by Group interaction). Only when the nature of the to-be-identified object was taken into account did the two tasks differentiate between groups. This relates to the second aim, which was to find out whether an impairment in reconceptualisation might be related to the category the objects belong to (animate vs. inanimate). We found that the requirement to reconceptualise brought out a specific deficit in the AS group in that they no longer showed an 'animate advantage'. The third aim was to investigate if deficiencies in the ability to form concepts, and/or switch between them, form a continuum underlying the entire population. The current results provided convincing evidence supporting this idea.

CHAPTER 5. (Re-)conceptualisation of Gaborised Objects in Asperger's Syndrome and Typically Developing Individuals

Abstract

Adults with Asperger's Syndrome (AS) and typically-developed adults (TD) were tested on a new task designed to measure the ability to identify animate and inanimate objects from impoverished images. In this task consecutive frames were presented each containing approximately 1000 static Gabor elements. From one frame to the next, some of the elements gradually aligned to form the contour-line of an object, while the elements in the interior of the object gradually adopted an identical orientation. Two versions of the task were used: (1) Conceptualisation Gabor Task: in the first frame of the sequence all Gabor elements had a random orientation, after which some aligned and the object gradually took shape. (2) Reconceptualisation Gabor Task: The Gabor elements in the first frame depicted object A (100%), which was identified by the participant. The contour line of this object remained physically present throughout the remainder of the sequence. From frame 2 onwards object B was gradually formed by elements in the background. The Reconceptualisation Gabor Task required that attention was disengaged from object A and was flexibly switched to object B. An essential feature of the Reconceptualisation Gabor Task in the current experiment was that the object from which one had to disengage remained physically present throughout the gradual appearance of the new object.

In the Conceptualisation Gabor Task, the AS group required significantly more frames to identify the objects than the controls. This was found to be the case in particular for the animate objects, and to a significantly lesser extent for the inanimate objects. In the Reconceptualisation Gabor Task, the AS group again required more frames to identify the objects than the controls, but this turned out to be purely caused by the animate objects. With respect to the inanimate objects, the AS group was as good as the controls. We conclude that the AS group has a specific problem with identifying animate, but not

inanimate, objects, and that this animacy deficit is made worse by the requirement to disengage from another object that remains physically present.

Introduction

A difficulty in forming new concepts, or in identifying categories, is one of the earliest cognitive deficits found in children with autism (Johnson & Rakison, 2006). Additionally, children with autism have been found to be compromised in categorising an object as either animate or inanimate, and in distinguishing an animate object from an inanimate object (Rutherford, Pennington & Rodgers, 2006). Developing a clear differentiation between animate and inanimate concepts is important for the child's understanding that different kinds of objects possess different physical, psychological, biological and motion related properties (Ratkinson & Poulin-Dubois, 2001).

The ability to understand the thoughts and intentions of others are abilities that TD children develop from a very young age (from 48 months onward; Cox et al., 1999). Such children show evidence of understanding epistemic mental states, such as 'knowing' and demonstrate that they understand the principle that 'seeing leads to knowing' (Pratt & Bryant, 1990; Baron-Cohen, 1995). It is argued that children and adults with autism fail to understand other's thoughts and intentions because they lack a theory of mind (Baron-Cohen, 1995), i.e. the ability to read the behaviour of others (and of oneself) in terms of epistemic mental states (e.g. desires and beliefs; Frith, Morton & Leslie, 1991; Baron-Cohen, 1995), and to empathize with others (Baron-Cohen, 2005). Some theorize that individuals with autism do understand intentions but fail socially because they lack the motivation to share intentions (Tomasello, 1988). However, it is also argued that this may be caused by a lack of perceptual integration skills that are needed to apply their basically intact theory of mind in complex social situations (Verbeke et al., 2005).

ASD and Animacy

Children and adults with ASD have anecdotally been described to be especially interested in inanimate objects (Cipolotti et al., 1999). In point light displays, individuals with autism have been found to be less likely to identify animate motion (Blake et al., 2003). When matching videos of people, as compared to matching videos of non-human stimuli (e.g. bird, dog, train, car) autistic children were much poorer at matching the human stimuli than controls, but were equally good in matching other types of stimuli (Hobson, 1987). Similarly, children with autism have been found to be better at discriminating between pictures of buildings than pictures of people (Bourcher & Lewis, 1992). Within-category deficits have also been noted in ASD, such as recognizing features of age and sex in people (Abelson, 1981, Hobson, 1993).

A number of studies have highlighted the specificity of the neural basis of animacy. For example, picture naming tasks activate the fusiform gyrus of both hemispheres (Kanwisher, et al., 1997), but selective areas of the fusiform gyrus have been found to be activated by different categories of objects. In particular, the lateral posterior fusiform gyrus has been found to be activated by faces (McCarthy et al., 1997), whereas tools have been found to activate the medial fusiform gyrus (Wiggett, Pritchard & Downing, 2009). Furthermore, cells in the superior temporal sulcus (STS) region have been found to be responsive to articulated body motions and posture in monkeys (Jellema & Perrett, 2003) and in typical humans (Allison, Pruce & McCarthy, 2000; Whatmough et al., 2002; Beauchamp et al., 2002; Downing et al., 2004). Interestingly, the STS has been shown to be anatomically and functionally compromised in ASD (Zilbovicius et al., 2006).

AS and Attention

The ability to switch concepts rapidly and accurately contributes to successful social interactions, as the mental states and intentions of the participants in a social interaction may change rapidly and at any time. Landry and Bryson (2004) found that children with autism have a marked difficulty in disengaging attention. On visual discrimination tasks, children with autism showed overly focused attention and have been described as having 'tunnel vision' (Rincover & Duncharme, 1987), which is related to a preference for detailed rather than global information processing (see the section below). This finding in children with autism is reminiscent of findings in typical infants of two months old, who are described to have 'sticky attention' (Johnson, Posner & Rothbart, 1991; Hood & Atkinson, 1993).

Abnormal eye gaze behaviour has been documented in autism (Scharre & Creedon, 1992). Individuals with autism have been found to make relatively fewer back and forth eye movements (Hermelin & O'Connor, 1967), and have a marked difficulty in focused visual attention (Kaland, Smith & Mortensen, 2008), joint visual attention (Mundy et al., 1986; Baron-Cohen, 1989), switching visual attention (Landry & Bryson, 2004) and disengaging visual attention (Landry & Bryson, 2004; Pascualvaca et al., 1998). When presented with two or more stimuli simultaneously, which requires rapid mental attentional orienting between different visual spatial locations, individuals with ASD have been shown to be compromised in object disengagement (Landry & Bryson, 2004). They have also been found to make less frequent shifts in attention between animate objects than between inanimate objects (Swettenham et al., 1998).

Tasks involving concept switching are often thought to involve the pre-frontal cortex and posterior parietal cortex (e.g. Sohn et al., 2000). Also the cerebellum has been implicated, especially in relation to autism, as individuals with ASD show similar patterns of impairment in shifting attention to individuals with cerebellar lesions (Courchesne et al., 1994).

AS and Central Coherence

Some theorists argue that, although there may be a general attentional deficit in autism, there may additionally be a focus on local details (i.e. elements constituting an object), which affects the processing of global or contextual information (Frith, 1989; 2003). This theory argues that the inability to pull together several strands of information in order to process it for higher-level meaning is the actual core deficit in autism (e.g. Happé & Frith, 2006). It may affect performance in face identification tasks (Deruelle et al., 2004), where autistic individuals have been found to exhibit a preference for focusing on the lower part of the face (Langdell, 1978). Individuals with ASD have been found to respond faster to local/small targets, while controls tend to respond faster to global/large targets (Plaisted, Swettenham & Rees, 1999). They have also been found to be impaired in visual processing of global motion stimuli (Spencer et al., 2000).

Superior ability of autistic adolescents and adults to find embedded figures suggests that autistic people have a special ability to see parts of objects, rather than wholes (Shah & Frith, 1983). Pellicano et al (2005) found global motion thresholds related to performance on this test. Autistic adults have also shown superior ability on the Block Design Task, a part of the Weschler Intelligence Tests (Shah & Frith, 1993). It is argued that individuals with ASD need less of the normally required effort to segment a gestalt, in line with the hypothesis of weak central coherence.

The Current Study

The Reconceptualisation study described in Chapter 3 (Burnett & Jellema, 2012) displayed silhouette pictures which were morphed interpolations between animate and/or inanimate objects (objects A and B). The participant had to identify the end-object (object B), which either started from the middle of the interpolation-sequence (50% object A, 50% object B) (Conceptualisation Task) or from the beginning of the sequence (100% A, 0% B) (Reconceptualisation Task). The current study is an extension of the study in Chapter 3, allowing to test two new objectives: (1) the influence of the continued physical presence of object A, and (2) the influence of local detail in the objects.

(1) The Silhouette task provided the participant with information about object B from very early on in the sequence (i.e. from the second frame depicting 95%A/ 5%B onward). The contribution of the start object reduced in each subsequent frame, until it had completely disappeared in the last frame (0%A/100%B). Thus the 'distractor' object did not remain physically present throughout the sequence, but gradually disappeared. What would happen if object A would remain physically present throughout the sequence? It has been suggested that physical reality may be more conspicuous, and have a greater impact, for individuals with ASD compared to TD individuals (e.g. Dawson & Lewy,1989). Thus in the new Gabor Reconceptualisation task, the start object will remain present and not morph into another object like the Silhouette Reconceptualisation Task, to increase the difficulty of concept identification. It will also investigate, whether the presence of Object A, for individuals with AS, more significantly impairs the identification of Object B.

(2) A feature of the Silhouette task was that it allowed the participant to process a significant amount of local information, derived from the uninterrupted contour-line of the object. Due to the preference for local processing in AS, it is possible that this gave the i important clues as to nature of end-object B. It is a further aim of the Gabor Reconceptualisation tasks, to reduce the amount of local information about the to-be-identified object, with a more 'global' contour of an object appearing, thus increasing the difficulty of the task.

In principle, the morphed pictures or 'gestalts' could be processed similarly to the way in which objects in the Embedded Figures Task or Block Design Task are processed, i.e. by segmenting the 'gestalt' into local elements in order to identity the object. Hence, the relative poor performance of the AS group in the Silhouette Reconceptualisation studies in Chapter 3 could still have benefited from a superior local processing mode. Therefore a specific aim of the current study was to reduce the amount of local information available to the participant. The rationale was that by reducing the amount of local information we might be better able to find a deficiency in processing animate objects in ASD, if there is such an deficiency. In other words, it would make the task more ‘sensitive’.

As in the Silhouette study, we tested the ability to form concepts from scratch and the ability to flexibly switch from one concept to another. The objects were formed from Gabor elements, against a background from other Gabor elements. A Gabor element takes the appearance of a rice grain. A subset of these Gabor elements gradually (over successive frames) aligns with the contour-lines of animate or inanimate objects. This had the effect of making the object gradually appear from out of a ‘mist’ of Gabor elements. We theorized that the recognition of the objects in the Gabor Tasks should become more difficult than in the Silhouette task due to a reduction in the amount of local information available to the AS participant, in both tasks, and particularly if the nature of the concept is animate.

Adults with AS and TD adults, that did not differ significantly in cognitive ability, were tested to see if the conceptualisation and reconceptualisation abilities are distinct and can be differentiated. That is to say; if a group is poor in reconceptualisation, would they then also have to be poor in conceptualisation? Or does a deficit only emerge when one has to disengage from a concept, while conceptualisation *per se* may be intact? A further aim was to find out whether an impairment in one or both of these abilities applies equally well to animate and inanimate objects.

Method

Participants

Two participants groups were used, a clinical group of students with AS and a control group of students with typical development (TD). The participants were a subset of those from the Silhouette (Re-)Conceptualisation study.

Clinical Group

Twenty students (15 males, 5 females; mean age = 21.5 years, SD = 6.1) with a diagnosis of AS or HFA, based on DSM-IV criteria (APA, 2000) were recruited through disability services at universities in the North-East of England (UK). Evidence of diagnostic history for ASD was acquired and the ADOS was completed with a trained examiner (HB; Autism Diagnostic Observation Schedule, module 4, *see Chapter 2).* All participants met the ADOS criteria for AS (mean total ADOS score = 8.0, SD = 0.92) as they did not have a history of language delay or a cognitive impairment, and were therefore included in the data analysis.

The participants had a mean IQ score of 117 (SD = 9.8; assessed using the Wechsler Adult Intelligence Scale, WAIS-III, Wechsler, 1997), and a mean score of 31.2 (SD = 8.4) on the Autism Quotient questionnaire (AQ, Baron-Cohen et al., 2001, *see Chapter 2, see Table 5.1 for sub-scores).*

Group	n	Age	Sex	AQ	IQ-T	IQ-V	IQ-P	ADOS
AS	20	21.5 (6.1)	5 F, 15 M	31.2 (8.4)	117 (9.8)	119 (13.7	112 (14.5)	8.2 (1.4)
TD	20	21.4 (3.5)	8 F, 12 M	11.9 (4.8)	113.4 (8.6)	117.7 (7.9)	107.8 (10.9)	

Table 5.1. Participant characteristics. Age is in years. Standard deviations are shown between brackets. F, female; M, male; AQ, Autism-spectrum Quotient; IQ-T, total IQ score; IQ-P, Performance IQ score; IQ-V, verbal IQ score.

Typically developed group

Twenty students (12 males, 8 females, mean age = 21.4 years, SD = 3.5) were recruited from the University of Hull. All TD participants completed an online version of the AQ prior to the experiment. As all participants scored at or below 'average' (0-22), all were included for analysis (Mean AQ = 11.9, SD = 4.8). The IQ was tested for 14 of the TD controls, using the WAIS III (Wechsler, 1997), the mean score was 113.4 (SD = 8.6) and did not differ from that of the AS group (M =117, SD = 9.8; p = .73).

All TD and AS participants had normal or corrected-to-normal vision, and provided written consent prior to the experiment. Participants received course credits or a fee for taking part. The study was approved by the Ethics committee of Hull University.

Stimuli

Similar to the previous study reported in Chapter 3 (Burnett & Jellema, 2012) for both the Conceptualisation and ReconceptualisationGabor Tasks, objects were selected from a large set of contour drawings (based on line drawings by Snodgrass & Vanderwart, 1980) of a wide range of animate and inanimate objects for which normative identification rates had been established (De Winter & Wagemans, 2004).

A trial consisted of 20 consecutively presented frames, with each fame containing approximately 1000 Gabor elements *(see Figure 5.1).* In the first frame of a sequence leading up to object B, all elements had a random orientation. From frame 2 onwards, a subset of 200 of these elements would change orientation in a coordinated fashion, with small orientation changes from one frame to the next. By doing so, they gradually, over the course of the 20 frames, formed the contour line of either an animate or inanimate object. In the last frame of the sequence, this subset of elements was perfectly aligned along the imaginary contour line of the object. The Gabor elements located outside the object continued to adopt random orientations throughout the entire 20 frame sequence, with small orientation changes between consecutive frames. The elements located inside the object, i.e. those that were enclosed by the contour line, gradually adopted an identical orientation (45 degree), again with small orientation changes from one frame to the next. Thus, in the final frame, the object could be identified on the basis of two cues: the object's contour line and the object's interior. The contour line was the most informative of the two cues. The maximum on screen height of the objects was 10 cm and maximum width was 14 cm. The light grey Gabor elements were presented against a dark grey background.

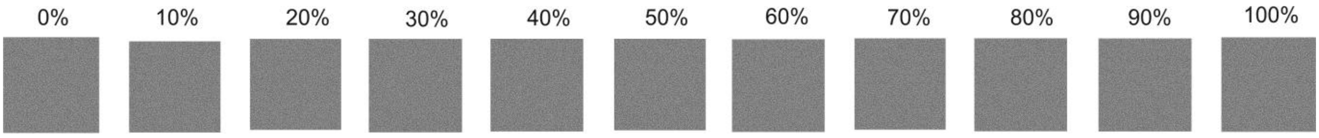

Figure. 5.1. Example of a Conceptualisation Gabor Task sequence (shown here in steps of 10% change) resulting in the image of a bear (far right). Note that in the task there are a total of 20 frames at 5% change.

To exclude the possibility that differences in the geometrical complexity of the images of animate versus inanimate objects could affect the recognition scores for these two categories, we qualified the complexity of the objects using two measures: compactness and homogeneity. Compactness is defined as (length contour line)/(surface area)^2. Homogeneity is defined as (length contour line)/(number of peaks)^2, where the number of peaks is based on an adaptive smoothing algorithm (Horng, 2003). Thus silhouettes with fewer peaks have higher homogeneity values. For both tasks, the end object silhouettes of animate and inanimate objects did not differ from each other in compactness or homogeneity. ConceptualisationGabor Task (28 animate and 28 inanimate objects): compactness, $t(54) = .27$, $p = .79$, two-tailed; homogeneity, $t(54) = 1.87$, $p = .066$; ReconceptualisationGabor Task (14 animate and 14 inanimate objects): compactness, $t(26) = .57$, $p = .57$; homogeneity, $t(26) = .078$, $p = .94$. In the ReconceptualisationGabor Task, the animate and inanimate start objects also did not differ from each other in compactness ($t(26) = .96$, $p = .35$) nor in homogeneity ($t(26) = .27$, $p = .79$).

Procedure

Similarly to the Silhouette study in Chapter 3, all participants completed an online version of the AQ questionnaire directly prior to the experiment (duration 5 minutes). Participants were then seated in front of a 21 inch PC monitor at a distance of approximately 1 metre, and instructed to sit back and relax throughout the experiment. All instructions and visual stimuli were presented on screen (E-prime, Psychology Software Tools Inc., Sharpsburg, USA; 600 x 800 resolution). All participants performed two tasks, a Conceptualisation Gabor Task and a Reconceptualisation Gabor Task *(see Figure 5.2).* The order of presentation was counterbalanced across participants. None of the end-objects in the Conceptualisation task was used as an end-object in the Reconceptualisation Gabor Task. The experimenter then verified the participant's understanding of each task, after which the experiments began. The exact duration of the experiment depended on the participant's performance, but lasted on average 20 minutes. Participants were told they could make unlimited verbal guesses as to what they thought the object was morphing into. The experimenter recorded all guesses made by the participant and the frame number at which the correct answer was given.

Task 1: Conceptualisation Gabor Task

Fifty-six trials were presented, of which 28 trials ended with an animate object and 28 with an inanimate object. The sequence started with a frame consisting of gabor elements, all of which had a random orientation. Therefore no object was present. Gradually an object would be formed (as described above; s*ee Figure 5. 2).* The first 10 pictures were shown in a rapid succession of 1 frame per second. Starting with frame 11 (50%), each picture was presented for 2 seconds, immediately followed by the next one (ISI = 0 ms). In this task the participant thus started off without a concept in mind. The number of interpolations needed to give the correct answer was recorded, as were all incorrect guesses.

Task 2: Reconceptualisation Gabor Task

Twenty-eight trials were presented, of which 14 trials ended with an animate and 14 with an inanimate object. All end-objects were different from those in the Conceptualisation Gabor Task. The Reconceptualisation Gabor Task was identical to the Conceptualisation Gabor Task, except that in the first frame of the sequence the contour-line of an object (Object A) was shown, formed by a subset of Gabor elements that were aligned along the object's contour (Gabors in the interior all had the same orientation, Gabors outside the object had random orientation). The participant was then asked to name object A (which was successfully done in all cases), so as to ensure that this concept was well in the participant's mind at the start of the sequence. The object A's contour-line then remained present throughout the subsequent 20 frames. From frame 2 onwards, a new object B was gradually formed (behind object A) exactly as in the Conceptualisation Gabor Task. In the last frame object's B contour line had been formed 100% *(see Figure 5.2).*

As in the Conceptualisation Task, the 10 frames following the first frame depicting the 100% object A were shown in a rapid succession of 1 frame per second. The next 10 frames (starting with 100% A / 50% B) were shown at a rate of 2 per second. Again, the number of interpolations needed to correctly name the emerging object, plus all incorrect guesses, were recorded. In this task the participant thus started off with a specific concept in mind, and a reconceptualisation needed to take place. In other words, concept A had to be traded in for concept B *(see Figure 5.2)*. Not later than a week after the experiment, the WAIS and the ADOS (only AS group) were administered.

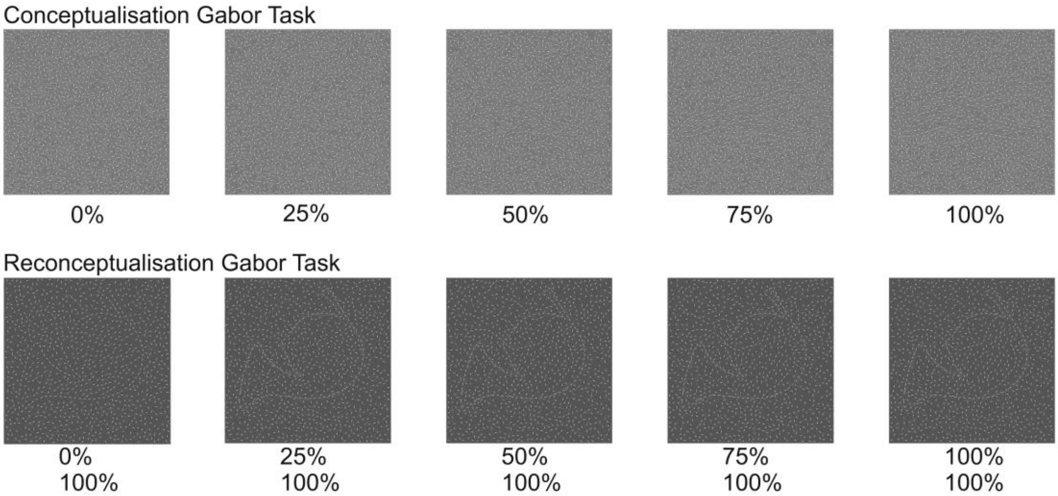

Figure 5.2.Schematic representation of the Conceptualisation Gabor Task and Reconceptualisation Gabor Task. The Conceptualisation Gabor Task started with an unidentifiable object (0% of object B) and ended in 100% object B. The Reconceptualisation Gabor Task started with 100% object A and 0% object B, and ended in 100% object A and 100% object B, superimposed on each other.

Results

We analysed the two tasks separately with 2x2 ANOVAs as different, non-matched, end-objects, and different numbers of end-objects, had been used in each task.

Conceptualisation Gabor Task.

The 2x2 repeated measures ANOVA, in which the within-subject factor was Endobject (animate vs. inanimate), and the between-subjects factor was Group (TD vs. AS) showed a significant main effect for End-object (F(1, 38) = 26.0, p < .001, η_p^2= .41), reflecting that overall the images of inanimate objects (M = 12.7, SD = 1.4) were easier to identify than those of animate objects (M = 13.5, SD = 1.6). The main effect for Group was also significant (F(1, 38) = 16.6, p< .001, η_p^2 = .30), reflecting that overall, the TD group performed better (M

= 12.4, SD = 1.4) than the AS group (M = 13.9, SD = 1.2). The Group x Endobject interaction was significant ($F(1, 38) = 9.8$, $p = .003$, $\eta_p^2 = .21$).

Subsequent *t* tests showed that the number of frames required by the TD group to identify the animate and inanimate objects did not differ ($t(19) = 1.26$, $p = .22$). The AS group required more frames to identify animate objects than inanimate objects ($t(19) = 6.6$, $p < .001$). Both animate and inanimate objects were more readily identified by the TD group than by the AS group (animate: $t(38) = 5.0$, $p < .001$; inanimate: $t(38) = 2.6$, $p = 0.13$).

Reconceptualisation Gabor Task.

The 2x2 ANOVA, with Endobject (animate vs. inanimate) as within-subject factor and Group (TD vs. AS) as between-subjects factor, showed a significant main effect for End-object ($F(1, 38) = 39.2$, $p < .001$, $\eta_p^2 = .51$). This reflected that overall the images of inanimate objects (M = 15.5, SD = 1.1) were easier to identify than those of animate objects (M = 16.4, SD = 1.9). The main effect for Group was also significant ($F(1, 38) = 29.3$, $p < .001$, $\eta_p^2 = .44$), reflecting that the TD group performed better (M = 15.1, SD = 1.2) than the AS group (M = 16.8, SD = 1.7). The Group by Endobject interaction factor was highly significant ($F(1, 38) = 139.7$, $p < .001$, $\eta_p^2 = .79$).

Subsequent *t* tests showed that the number of frames required by the TD group to identify the animate and inanimate objects did not differ ($t(19) = 3.8$, $p = .001$). The AS group required considerably more frames to identify animate objects than inanimate objects ($t(19) = 13.1$, $p < .001$). Animate objects were more much more readily identified by the TD group than by the AS group ($t(38) = 10.9$, $p < .001$). However, with respect to the recognition of inanimate objects the two groups did not differ ($t(8) = .52$, $p = 0.61$).

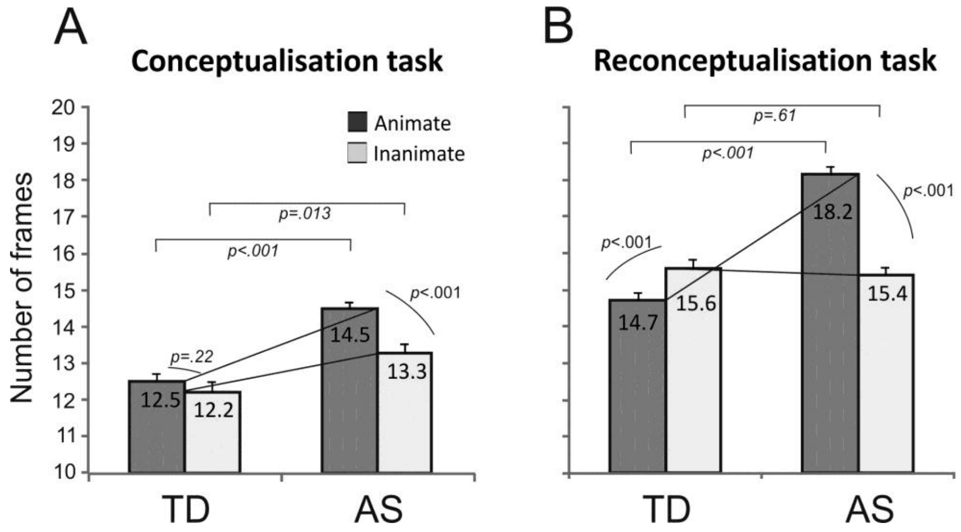

Figure 5.3.The results on the Conceptualisation Gabor Task (A) and Reconceptualisation Gabor Task (B). The mean number of images required to correctly identify the object is shown for the two participant groups, the AS and TD groups. Linear trend lines and standard errors (SEM) are shown.

To obtain an indication of the influence of the continued physical presence of object A on the recognition of object B (reconceptualisation) in the AS group, we subtracted the mean score of the control group from the individual scores of the AS groups, in both tasks *(see Figure 5.4).* This 'normalised' the AS scores (number of frames), and effectively removed influences due to the use of different object sets in the two tasks. The normalised number of frames required by the AS group to recognise animate objects had significantly increased in the Reconceptualisation Task compared to the Conceptualisation Task ($t(19) = 6.5$, $p<.001$; paired-sample t test). However, the normalised number of frames required by the AS group to recognise inanimate objects had significantly decreased in the Reconceptualisation Task ($t(19) = 4.6$, $p<.001$; paired-sample t test). The conclusion is that reconceptualisation, as expected, did impede the recognition performance of the AS group, but only for animate objects. Surprisingly, with respect to inanimate objects, reconceptualisation did not impede recognition but rather enhanced it.

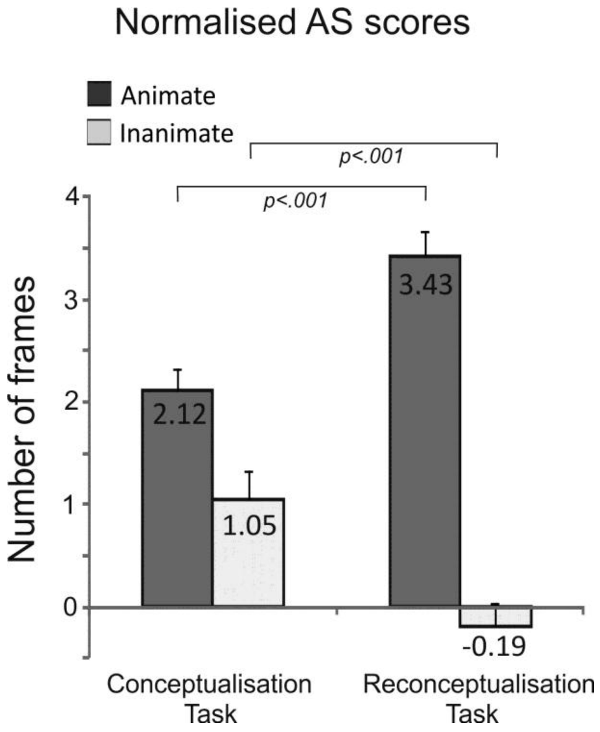

Figure 5.4. The normalised scores of the AS group in both tasks. The scores reflect the extent to which the AS group differed from the controls. A score of zero indicates no difference between control and AS group. Positive scores indicate that the AS group required more frames to identify the object than the controls, negative score that the AS group required less frames than the control group.

Did the presence or absence of a switch in category between start- and end-object affect the recognition of the end-object?

In the Reconceptualisation Task, we further looked whether there was an interaction between the animate or inanimate nature of the two objects. That is, would a switch in category of the first object (which remained present throughout the sequence) and the end object (which was gradually formed in the foreground of the first object) hamper the recognition of the end-object? A 2x2x2 ANOVA in which the within-subject factors were the Start- and End-object (both animate or inanimate) and the between-subjects factor was

Group (TD and AS) revealed a significant three-way interaction (F (1, 38)= 5.06, p =.03, η_p^2 = .117). We therefore performed separate two-way ANOVAs for each group.

TD Group

There were significant main effects for the Start-object (F(1, 19)= 11.6, p =.003, η_p^2 = .38), and for the End-object (F(1, 19) = 14.4, p = .001, η_p^2 = .43). The interaction between Start- and End-objects was highly significant (F(1, 19) = 27.6, p< .001, η_p^2 = .60). This interaction was due to the animate end-objects being earlier recognised when the start-object was also animate (M = 13.8) than when the start-object was inanimate (M = 15.7; t(19) = 8.38, p< .001). Recognition of inanimate end-objects was not affected by the nature of the Start-object (t(19) = 1.1, p = .284). Thus, in the TD group, identification of the end-object was affected by the nature of the start-object, but in a rather specific way. That is, facilitation of identification of the end-object only occurred for animate end-objects that were preceded by an animate start-object *(see Figure 5.5).*

AS Group

There was no significant main effect for the Start-object (F(1, 19)= 3.7, p = *.068*, η_p^2 = .165), but the main effect for the End-object was highly significant (F(1, 19)= 156.1, p <*.001*, η_p^2 = .90), reflecting that for the AS group inanimate objects were much easier to identify than animate objects.However, there was no significant interaction between Start-object and End-object (F(1, 19)= .215, p = *.65*, η_p^2 = .011). Thus, in contrast to the TD group, for the AS group the recognition of the end-object was not affected by the nature of the start-object *(see Figure 5.5).*

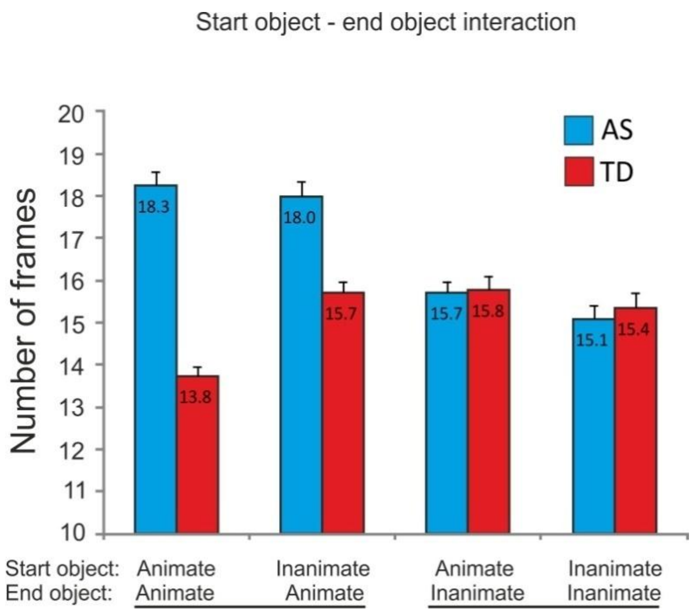

Figure 5.5. The start/end object comparisons for the Reconceptualisation Gabor Task. The mean number of images required to correctly identify the animate or inanimate end-object is shown for the AS and TD groups, with animate or inanimate start objects.

Analysis of incorrect guesses

All incorrect guesses made by all participants before they correctly identified the end-object were recorded on both tasks, to be able to determine whether any differences existed between the two participant groups in absolute number of guesses, and/or differences in the relative numbers of animate and inanimate guesses.

Across both tasks, the number of guesses (before the correct guess was made) by the TD and AS groups were very similar. The mean number of guesses per trial for the TD group was 0.23 (SD = 0.18), and for the AS group 0.25 (SD = 0.18), which did not differ significantly from each other ($t(78) = .65$, $p = .52$) *(see Figure 5.6).*

From all the guesses made by the TD group, 68.2 % (SD = 22.8%) was animate, and 31.8% was inanimate. This meant the TD group made significantly more animate than inanimate guesses ($t(39) = 4.4$, $p < .001$). From all the guesses made by the AS group, 60.9 % (SD = 13.8%) was animate, and 39.1% was inanimate. The AS group, like the TD group, made significantly more animate than inanimate guesses (*t*(39) = 4.1, *p*< .001). Direct comparison of the percentages of animate guesses made by the TD and AS groups showed that the proportions of animate and inanimate guesses did not differ (*t*(76) = 1.7, *p* = .093).

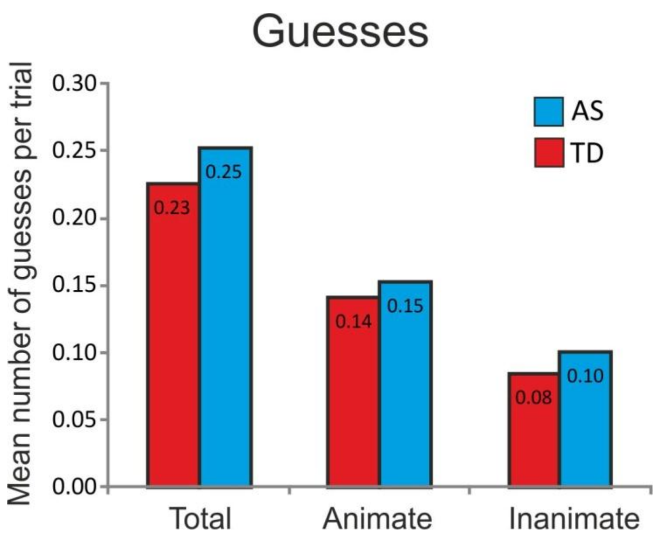

Figure 5.6. Guesses made before the correct response was given. The mean total guesses, animate and inanimate guesses made by the two groups in the Conceptualisation Gabor Task and Reconceptualisation Gabor Task are shown.

IQ

To rule out intelligence as a potential variable, an analysis of covariance (ANCOVA) was performed between Groups (TD vs. AS), Endobject (Animate vs Inanimate) and IQ (Verbal and Perceptual). In the Gabor Conceptualisation Task, no significant difference was found between endobject and verbal ($F(1, 29) = 7.4$, $p = .011$, $\eta_p^2 = .203$) or perceptual ($F(1, 29) = 6.05$, $p = .02$, $\eta_p^2 = .173$) intelligence. Similarly, in the Gabor Reconceptualisation Task, no significant difference was found between endobject and verbal ($F(1, 29) = .184$, $p = .671$, $\eta_p^2 = .006$) or perceptual ($F(1, 29) = .005$, $p = .945$, $\eta_p^2 = .000$)

Discussion

The present study was designed to test the hypothesis that individuals with Asperger's Syndrome (AS) have a deficit in forming new concepts and/or in disengaging from one concept in order to form a new one. We further investigated whether it mattered if the nature of the object that had to be identified was animate or inanimate. For this purpose, we used two simple tasks involving Gabor elements, a subset of which changed its orientation slightly from one picture to the next, so as to gradually align along the contour-line of an object. This gave the illusion that the object gradually appeared out of a 'fog' or 'mist'. The Conceptualisation Gabor Task involved no concept switching, the participant simply had to form a new concept from scratch. The Reconceptualisation Gabor Task required the ability to disengage attention from one stimulus to actively form a new concept.

The current study was an elaboration of the study described in Chapter 3 (Burnett & Jellema, 2012), where silhouette pictures of morphed objects were presented in a similar format. In the previous study we found that the AS group performed similarly to TD individuals in both tasks when identifying inanimate objects. However, the AS group showed a profound deficit in the Reconceptualsation Gabor Task when identifying animate objects. The aim of the current study was to test this paradigm further by reducing the local information available to the participant, which would make the task more difficult, especially for those who rely on local detail to identify objects. .We also changed the format of the task by keeping the start-object present throughout the sequence, instead of gradually reducing the amount of information of the start-object as in the Silhouette task. Both changes (less local information and the continued physical presence of the 'distractor' object) would increase the difficulty of the task. We hypothesised that individuals with AS would show an increased deficit in object recognition, especially in the Reconceptualisation Gabor Task.

Deficit in Concept Formation

Performance of the AS group indicated that, compared to TD individuals, they were impaired in forming both animate and inanimate concepts. This deficit was larger for animate objects. The findings support previous research that there is a general deficit in forming concepts in ASD (Johnson & Rakison, 2006). As the deficit was larger for identifying animate objects, the findings support the idea of a general processing deficit for animacy (e.g. Hobson, 1987).

Deficit in Concept Switching

On the Reconceptualisation Gabor Task the AS group performed quite similarly to controls task when the endobject was inanimate, but required significantly more frames when the object was animate. The finding that with respect to inanimate object the two groups did not differ does not support the notion of a general attentional deficit (Landry & Bryson, 2004). At first this may seem surprising, however, the findings would be consistent with the idea that individuals with autism have a deficit in switching concepts when the nature of the new concept is animate (Dawson & Lewy, 1989). This specific animate deficit might become more prominent under conditions where it is difficult to disengage from the ‘distractor’ object, such as in the current task where the start-object remained physically present throughout the task. This might explain why the deficit in the identification of animate objects (as compared to inanimate objects) is larger in the current Gabor Tasks than in the previous Silhouette task. One could speculate about what the consequences of a processing deficit for animate objects could have on daily social interactions. It would make these interactions more cumbersome as they typically involve a lot of ‘animate concept switching’, and it might even impact on the forming of a theory of mind.

Did the assumed deficit in processing global information in the AS group impact on the results ?

One aim of the present study was to reduce the amount of local information about the end-object available to the participant in the Reconceptualisation Gabor Task, to see whether this would affect performance of the AS group more than that of the TD group, given that the former group is thought to be compromised in global processing. Frith (1989) argued that the tendency for TD individuals to process incoming information for meaning and gestalt (global) form, is often at the expense of details and surface structure. Individuals with ASD are hypothesised to have weak central coherence and to show a processing bias for local information. It seems that the emphasis on global processing in the Reconceptualisation Gabor Task indeed 'brought out' the deficit for animate processing better than the Silhouette (Re-) Conceptualisation study did. This might very well be related to the fact that the AS group could not rely on local detail in the way they did in the Silhouette task.

A deficit in processing animacy?

We propose that the animacy deficit, found in the AS group was due to an impaired ability to process and identify animate objects, which was increased in the Reconceptualisation Gabor Task due to the additional requirement of having to switch between concepts. However, there are a number of alternative explanations that need to be examined first.

(i)_Could the difference in shape and complexity of the animate and inanimate objects explain the different identification rates?

It is possible to argue that the form of the animate objects was more complex than that of the inanimate objects. Such increased form complexity could have selectively disadvantaged individuals with ASD. For example, it has been shown that with increased spatial distance between visual stimuli, individuals with ASD tend to respond to only some features and fail to respond to others (Rincover & Ducharme, 1987). However, the compactness and homogeneity scores did not differ between animate and inanimate objects, indicating that the two categories were equally complex in terms of their shapes. Further, a greater familiarity of the animate objects as compared to the inanimate objects is also an unlikely factor, as the controls were better in identifying animate than inanimate objects, suggesting that, if anything, the animate objects were more familiar. The AS group, however, showed a marked deficit for the animate objects.

(ii)_Did the AS and TD group have different guess-patterns that might explain the different identification rates?

One could argue, for example, that if one group would make a lot more guesses than the other group, or a lot more guesses in a specific category, then their chances of making a correct guess (in a specific category) would bigger. In principle it could also be that the real problem is not so much in correctly identifying the object, but in generating a range of different guesses. A failure to generate many guesses could reflect a 'hard-wired' cognitive deficit, but it could also reflect specific task setting. For example, the AS group might make fewer guesses because the guesses in this study had to be made verbally to the examiner, which in a way is a social response (in contrast to pressing keys on a keyboard). This in itself could have caused the AS group to generate fewer guesses. Another argument could be that the AS group might have less exposure to animate objects and that they therefore would be less likely to generate animate guesses, and therefore be less likely to guess the identity of the animate objects correctly.

However, the analysis of the wrong guesses (number of guesses made until the correct guess was made) indicated that any differences in identification of the gaborised objects in the two tasks could not be explained by the employment of different guess strategies. The analysis showed that the two groups did not differ in total number of guesses made, nor in the proportions of animate and inanimate guesses. Thus all of the above possibilities have to be rejected. This suggests that the differences in identification of the objects we found between the groups was not due to an inability to access, and then verbalise, animate concepts *per se*, but rather to a failure to access the correct animate concept.

(iii) Could a deficit in establishing general abstract categories have selectively disadvantaged the recognition of animate objects?

As discussed in chapter 3, it is possible that a deficit in establishing general abstract categories selectively disadvantaged the recognition of animate objects. Landry and Bryson (1994) found that children with autism were relatively impaired in forming general abstract categories. It could be that the AS group found it particularly difficult to establish the general category to which a specific object belonged, when that general category is comprised of objects that differ widely from each other in shape and appearance. One example provided by Grandin (1995) is the category of dogs. If the abstract concept of a dog is lacking, then, in order to identify a newly encountered breed of dog as a dog, the memory for already established examples of dog breeds needs to be deliberately updated with the new breed. However, most exemplars of animate subclasses that were used in the current study (e.g. butterfly, chicken, penguin) do not come in such big varieties as dogs. Moreover, the inanimate objects that were used also come in large varieties (e.g. sofa, lamp, and hat). It therefore seems unlikely that a deficit in establishing general abstract categories could have selectively disadvantaged the recognition of animate objects in the current study.

As these alternative explanations have to be rejected, we hypothesise that the most likely explanation for the results found in the current study are an underlying processing deficit for animate objects in AS. Such an animacy deficiency could be related to deficiencies in the so called ‘social brain’ (Brothers, 1990; Dunbar, 1998; Adolphs, 1999; Allison, Puce & McCarthy, 2000). Several studies have found reduced activity in social brain areas in autistic individuals (Baron-Cohen et al., 2001; Castelli et al., 2002; Dapretto et al., 2006). Single neuron recordings (e.g. Jellema & Perrett, 2002), human lesion studies (e.g. Warrington & Shallice, 1984) and imaging studies (e.g. Beauchamp et al., 2002; Wheatly, Milleville & Martin, 2007; Fuggetta et al., 2009) have all highlighted the dissociation between the representations for animate and inanimate objects, by showing that these object categories activate distinct and different cortical areas.

It is possible that although there is a general concept formation and switching deficit in ASD, that this is more evident for animate stimuli. Dawson, Meltzoff et al (1998) found that children with autism were relatively impaired in tasks involving joint and shared attention. However, they performed similarly to controls when attention performance was measured for orientation to non-social stimuli. Dawson and Lewy (1989) proposed that there is a general attentional deficit in autism, which becomes more evident when the stimulus is animate. Their attentional deficits may cause children with autism to miss out on social experiences, which provide the foundations for social development (Dawson, 1991).

Summary

In summary, the aim of the current study was to determine whether the abilities of conceptualisation and reconceptualisation can be differentiated in AS. The current results indicate that the tasks affected the TD and AS groups differently. Both groups found the Reconceptualisation Gabor Task significantly more difficult than the Conceptualisation Gabor Task. However, on the Conceptualisation Gabor Task the AS group performed significantly poorer when the endobject was animate, while the TD group performed equally well for the two categories. This effect was heightened when there was the requirement to first disengage from another stimulus. Further aims were to examine whether the added difficulty of the persistent presence of the start-object, and reduction of local information, would increase the animacy deficiency effect found in the Silhouette study (Burnett & Jellema, 2012). The results clearly indicated this to be the case.

The findings of the current study support a deficit for processing animacy in AS. However, a general concept formation deficit was also found. This deficit increased when the nature of the stimuli was animate and when first having to disengage attention from another stimulus. The current study provides a convincing argument for attentional deficits in AS when the nature of the object is animate.

CHAPTER 4. (Re-)conceptualisation of Silhouette Objects in Children with and without Autism Spectrum Disorder

Abstract

The same two tasks (in Chapter 3) were used to investigate the abilities to form new concepts from scratch (conceptualisation) and to flexibly switch from one concept to another (reconceptualisation), in children diagnosed with severe Autism Spectrum Disorder (ASD), children with mild ASD, and typically-developed children that did not differ significantloy in cognitive ability to the ASD groups. In consecutively presented morphs, containing increasing percentages of animate or inanimate objects, the emerging objects had to be identified. Overall, the control children showed a greater ability for recognising animate objects than the children with ASD, but they did not differ significantly from each other when identifying inanimate objects. Children in the ASD group with low cognitive ability and profound autistic traits showed an advantage for inanimate objects when reconceptualisation was required. The results suggest children with ASD are impaired in the forming of, and switching toward, animate concepts.

Introduction

As social interaction involves complex, and above all unpredictable events, such as changes in facial expressions, speech and gesture (Dawson & Lewy, 1989), it is a crucial step in child development to be able to rapidly and accurately form new concepts and switch between concepts (e.g. trade in an existing concept for a new one). Children with autism have been found to fail at understanding or predicting emotional states in people (Boucher & Lewis, 1992; Buitelaar et al., 1991).

Mechanisms underlying ASD

In early social exchanges, children are required to rapidly shift attention between different stimuli, in particular when sharing attention with others, which children with autism often find difficult (Courchesne, Chisum & Townsend, 1995). It is argued that these social communication deficits in ASD are (partly) caused by a deficiency in executive functioning skills (Robin et al., 2006), such as cognitive flexibility (Geurts et al., 2004), concept switching (Delis, Kaplan & Kramer, 2001), planning (Ozonoff & Jensen, 1999) and inhibition (Hill & Bird, 2006).

Other theories argue that the deficits in social cognition are primarily due to the child's failure to develop a theory of mind (Baron-Cohen, 1995). The 'Theory of Mind' model proposes that the development of mind depends, among other things, on a shared attention mechanism, which is an early precursor to social cognitive development (Rutherford, Pennington & Rogers, 2006). Children with ASD often fail to orient to social stimuli, such as their name being called (Dawson et al., 1998), and typically do not recognise that others have mental states such as beliefs, desires, intentions (Baron-Cohen, Leslie & Frith, 1985; Baron-Cohen, 1991). An inability to mindread also explains why an autistic child fails to spontaneously participate in pretend play, as they do not understand the mental state of 'pretend' (Wing & Gould, 1979; Baron Cohen, 1987).

However, the theory of mind is said to ignore other characteristic deficits in domains such as language, imagination and motor behaviour (Volkmar et al., 2004), while focussing primarily on social deficits. It is also argued that individuals with ASD's may have an intact theory of mind but have a deficiency in perceptual integration, which prevents them from successfully applying it in complex social situations (Verbeke et al., 2005).

The Central Coherence Theory (Frith, 1989) argues that the 'deficit' in autism basically reflect a difference in cognitive style (Happé, 1999), postulating that individuals with ASD do not pull together incoming information in its context to process a higher level meaning.

Individuals with ASD have indeed a tendency to focus on the local detail and therefore miss the greater global picture (Happé & Frith, 2006).

Concept forming and concept switching in children with ASD

As most tasks involve presenting multiple stimuli simultaneously, it is often difficult to disassociate concept formation and concept switching as two separate abilities. The two functions are distinct in nature, concept forming refers to the ability to form a new concept (from scratch), without already having a concept in mind, while concept switching refers to the ability to form a new concept when another concept was held in mind, e.g. it involves disengagement from an existing concept. Deficits in attention switching have previously been linked with specific brain areas, e.g. the cerebellum (Courchesne et al., 1994) and the pre-frontal cortex (Brambilla et al., 2003)

Children with ASD have been found to show profound deficits in tasks requiring flexibility in allocating attention, such as tasks of joint attention (Mundy et al., 1986; Baron-Cohen, 1989, 1995; Buitelaar et al., 1991), focused attention (Kaland, Smith & Mortensen, 2008) and attention switching (Landry & Bryson, 2004; Pascualvaca et al., 1998). They have been found to make less eye movements between simultaneously presented stimuli (Landry & Bryson, 2004; Swettenham et al., 1998) and to be poorer at disengaging from stimuli (Hughes & Russell, 1993). Individuals with AS and High functioning autism are said to occupy successive positions on an attentional spectrum, suffering similar deficits to individuals with classical autism but to a lesser extent (Hill, 2004; Kleinhans, Akshoomoff, & Delis, 2005).

ASD and animacy

Social development in young children relies on the ability to use and understand social or animate stimuli. Proper understanding of verbal and non verbal bodily cues such as eye gaze (Vecera & Johnson, 1995), facial expression (Ekman & Friesen, 1975; Malatesta & Haviland, 1982) and gestures/language (Bruner, 1983) is crucial to evaluate the social communicative intentions of others. By the age of four, the normal child can recognise familiar faces and voices at nearly adult level (Bartholomous, 1973; Ellis, 1990). During the early stages of life, children with autism have noticeable deficits in social interaction, failing to use appropriate facial expressions (Kanner, 1943) and social smiling (Adrien et al., 1992), failing to respond to their name being called (Zakian et al., 2000), a lack of spontaneous pointing (Ostering & Dawson, 1994), and a failure to recognise familiar faces and voices (Boucher & Lewis, 1992). It is argued that the most profound and characteristic cognitive deficits, for most children with ASD, are the social deficits (Rutherford et al., 2006). They have been shown to fail in tasks involving the spontaneous or involuntary processing of social cues (Senju et al., 2009; Jellema et al., 2009). Young children diagnosed with autism have been found to show a preference for mechanical toys such as cars and trucks than for social toys such as dolls (Charman et al., 1997).

There is growing scientific evidence that children with ASD do have specific problems in dealing with animate stimuli as compared to inanimate stimuli (e.g. Hobson, 1997; Boucher & Lewis, 1992; Dawson & Fernald, 1987; Baron-Cohen & Swettenham, 1997; Derulle et al., 2004). Children with autism have been found to be better at discriminating between and recalling events of pictures/videotapes of mechanical, inanimate stimuli, than of animate stimuli and images of people (Hobson, 1983; 1987; Boucher & Lewis, 1992; Boucher, Lewis & Collins, 1998; Bowler & Thommen, 2000). They have also been shown to be better at categorising objects as animate on the basis of their motion after reaching a criterion level, thus showing that animacy perception might be preserved in ASD, even if it is not used automatically (Rutherford et al., 2006). Furthermore, autistic children have been shown to be more interested in inanimate stimuli than animate objects (Hobson, 1987; Sweetenham et al., 1998; Cipolotti et al., 1999; Blair et al., 2001).

The current study

The rationale of the current study is similar to that of the tasks in Chapter 3 (Burnett & Jellema, 2012). The tasks in Chapter 3 investigated the abilities to form new concepts from scratch (conceptualisation), and to flexibly switch from one concept to another (re-conceptualisation) in adults with Asperger's Syndrome (AS) and in typically-developed (TD) adults with low and high autism spectrum quotients. The findings of the previous study were that the ability to reconceptualise became increasingly impaired with increasing autistic (-like) traits, especially with respect to animate objects. We aimed to extend this investigation to children with spectrum disorder (ASD), which display a wide variety in the severity of autistic symptoms. Children with ASD were divided into two groups, depending on the severity of autistic symptoms: the low-functioning or Autism group and the high-functioning (HFA)/ AS group. Control groups consisted of TD children, that did not differ significantly in verbal and non-verbal cognitive ability to the two ASD groups.

The study described in the previous chapter on TD adults with low and high scores on the AQ and adults with AS already suggested that concept formation and concept switching are distinct abilities, which can be differentiated. That is, if a group is poor in reconceptualisation, they do not necessarily also have to be poor in conceptualisation. If the abilities to form concepts and to switch between them is indeed distributed along a continuum underlying the entire population, including individuals with ASD, then one would expect the AS group to outperform the Autism group. Another aim was to find out whether an impairment in one or both of these abilities is a general feature that applies equally well to all categories of objects, or whether there are categories that are more susceptible than others. As in the previous chapter, we specifically contrasted animate and inanimate objects, as there is growing evidence that individuals with ASD are somehow impaired in processing animate objects as compared to inanimate objects.

If deficiencies in the ability to form concepts, and/or switch between them, indeed forms a continuum underlying the ASD population, as suggested by the study on adults in the previous chapter, than one would expect the AS group to outperform the Autism group.

Method

Participants

Clinical groups

The clinical groups consisted in total of thirty children recruited through child and adolescent mental health services (CAMHS) and schools in the North-East of England (UK). All these children had previously received a diagnosis of autism or AS, based on DSM-IV criteria (American Psychiatric Association: APA, 2000). These diagnostic evaluations involved a review of prior psychology records/psychiatric observation and the ADOS (Autism Diagnostic Observation Schedule, module 4: Lord et al., 1999). Parents were asked to complete the Adolescent AQ (Ad-AQ: for 11-15 year olds) about their child (Baron-Cohen, Knickmeyer & Wheelwright, 2006) as an additional screening tool. No children were excluded, besed on their Ad-AQ or ADOS scores.

The individual children varied quite widely in the severity of autistic symptoms, as well as in their overall intellectual ability. The clinical groups were separated based on the ADOS criteria for either autism or AS. For the group of children who met the criteria for autism, their cognitive functioning was well below average, when assessed using the Wechsler Intelligence Scale for Children, (WISC-IV, Wechsler, 1991), and were therefore described as low-functioning ASD *(see Table 4.1 for details).* The group of children who met the criteria for AS showed cognitive functioning which was within the average range, assessed using the Cognitive Ability Tests CAT-3 (Lohman, Hagen & Thorndike, 1995). The ASD groups did not differ significantly from the control groups in terms of their verbal ($t(58) = 1.32$, $p=.193$) or non-verbal ($t(58) = .557$, $p=.58$) cognitive ability.

1) Asperger's Syndrome Group

The fifteen children included (11 males, 4 females; mean age = 13.1 years, SD = 1.0) had a mean total ADOS score of 8.2 (SD = 0.9, range: 7-9). Their mean cognitive ability score was 94.1 (SD = 13.6), assessed using the CAT-3, and their mean AQ score (completed by their parents) was 35.7 (SD = 5.3*) (see Table 4.1).* The children conformed to the criteria for AS as they all had impaired social communication and skills and repetitive behaviours of various kinds, but no language disturbances (cf. Asperger, 1944).

2) Autism Group

The fifteen children included (12 males, 3 females; mean age = 14.8 years, SD = 2.2) had a mean total ADOS score of 14.7 (SD = 4.9, range: 10-27). Their mean IQ score was 72.3 (SD = 12.3; assessed using the WISC-III) and their mean AQ score was 27.4 (SD = 9.9) *(see Table 4.1).* The children conformed to Rutter & Schopler's (1978) criteria for the diagnosis of autism. All had impaired language ability and communication skills, impaired social skills and repetitive behaviours of various kinds.

Control groups

3) High Functioning Control Group

Fifteen children were recruited through typical schools in the North-East of England. The group consisted of 10 males and 5 females (mean age = 13.3 years, SD = 1.3). The mean IQ score was 106.5 (SD = 7.1), assessed using the CAT-3. Parents were asked to complete the Adolescent AQ (11-15 years; Baron-Cohen et al., 2006). The mean AQ score was 13.3 (SD = 4.4) *(see Table 4.1).* The WISC and CAT-3 tests scores have been shown to correlate highly (Wright, Strand & Wonders, 2005) and the CAT-3 test is the most widely used cognitive ability test used in the UK, adopted by all mainstream schools. It has been found to be a reliable estimation of intellectual ability in children (Wright et al., 2005) *(see Table 4.1* for details).

4) Low Functioning Control Group

Fifteen children were recruited through schools and disability services in the North-East of England. The group consisted of 9 males and 6 females (mean age = 14.1 years, SD = 1.3). Parents were asked to complete the Adolescent AQ (11-15 years; Baron-Cohen et al., 2006), which was used as a screening tool for autistic traits. Their mean AQ score was 22 (SD = 4.1). All children completed the ADOS as an additional exclusion criterion, administered by HB. Their mean total ADOS score was 1.9 (SD =1.3, range 0-4). No children were excluded based on either measure. Their mean IQ score was 71.7 (SD = 12.7), assessed using the WISC-III (*see Chapter 2)*.

GROUP		n	Age	Sex	AQ	Cognitive Test	IQ-T	IQ-V	IQ-P	ADOS
CHILDREN	AS	15	13.1 (1.0)	11 M, 4 F	35.7 (5.3)	CAT-3	94.1 (13.6)	94.1 (11.4)	94.9 (13.1)	8.2 (0.9)
	HF-Control	15	13.3 (1.3)	10 M, 5 F	13.3 (4.4)	CAT-3	106.5 (7.1)	105.4 (11.5)	107.5 (13.3)	
	Autism	15	14.8 (2.2)	12 M, 3 F	27.4 (9.9)	WISC-III	72.3 (12.3)	73.4 (14.9)	75.5 (12.0)	14.7 (4.8)
	LF-Conrtol	15	14.1 (1.3)	9 M, 6 F	22.0 (4.1)	WISC-III	71.7 (12.7)	74.8 (15.4)	68.8 (14.3)	1.9 (1.3)

Table 4.1. Participant characteristics. Age is in years. F, female; M, male. AQ, Autism-spectrum Quotient. CAT-3-T, total score, V, verbal score, P, non-verbal-performance score. WISC-IQ-T, total IQ score. IQ-P, Performance IQ score. IQ-V, verbal IQ score. Standard errors are shown between brackets.

All Control and ASD participants had normal or corrected-to-normal vision, and provided parental written consent prior to the experiment. Participants participated voluntarily in the study. The study was approved by the Ethics Committee at Hull University.

Stimuli

The stimuli used in these experiments was identical to the stimuli used in Chapter 3 (Burnett & Jellema, 2012), for both the Conceptualisation and Reconceptualisation Tasks *(see example: Figure 4.1 and 4.2).*

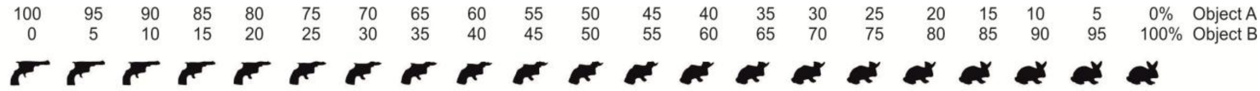

Figure 4.1. Example of a morph-sequence of a gun (far left) and a rabbit (far right) in steps of 5% change. Note that the object consisting of 50% gun and 50% rabbit, midway the sequence, cannot be identified as either of them without prior knowledge of two end-objects.

Procedure

Prior to the experiment, parents of all children in the ASD and control groups completed the child 11-15 years version of the AQ, which takes around 5 minutes to complete. All participants in the clinical group and children in the control group, who had a cognitive impairment, completed Module 3 or 4 of the ADOS (depending on the child's chronological age and cognitive ability), which took around 40-60 minutes, with examiner HB. Children in the autism and the low functioning control group, who did not have a recent assessment from an Educational Psychologist, containing a WISC assessment, were asked to complete the WISC-III in addition to the ADOS. From children in the Asperger's and high-functioning control group, CAT-3 scores were obtained by their class teacher at school.
The further experimental procedure was identified to the procedure in the previous chapter (*see Chapter 3).*The two tasks (Conceptualisation and Reconceptualisation) were identical to those described in the previous chapter (*see Chapter 3 and see Figure 4.2).*

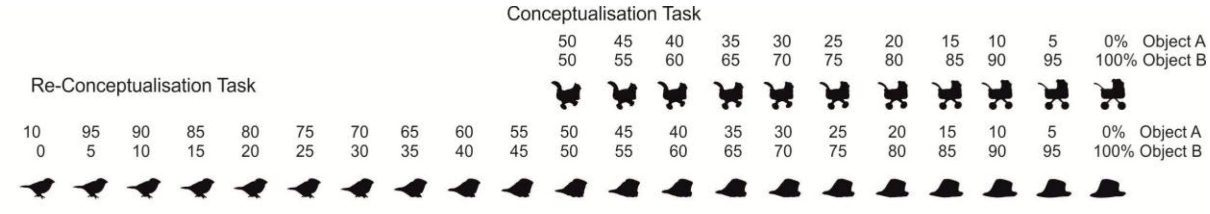

Figure 4.2.Schematic representation of the Conceptualisation and Reconceptualisation Tasks. The Conceptualisation Task started with an unidentifiable morphed object consisting of 50% of object A and 50% of object B, and ended in object B. The Reconceptualisation Task started with 100% object A, and ended in 100% object B.

Results

We tested four different groups, which varied along two dimensions, each with two levels. The two dimensions were: Level of functioning (High: Control-HF and AS groups, and Low: Control-LF and Autism groups) and Status (Clinical: AS and Autism groups, and Control: Control-HF and Control-LF groups). We thus started off with a 2x2x2x2 ANOVA in which the within-subject variables were Task (Conceptualisation vs. Reconceptualisation) and Endobject (animate vs. inanimate), and the between-subject variables were Level of functioning (high vs. low) and Status (Clinical vs. Not-clinical).

The main effect of Endobject was highly significant (F(1, 56) = 223.9, $p < .0001$, $\eta_p^2 = .80$), reflecting that overall animate objects were quicker recognised than inanimate objects. This could in principle be due to animate objects being inherently easier to identify, e.g. because they might be more familiar, or it could reflect a processing advantage for animate objects relative to inanimate ones. The main effect of Task was non-significant (F(1, 56) = 1.3, $p = .26$, $\eta_p^2 = .023$). The main effect of the between-subjects factor Status was significant (F(1, 56) = 35.4, $p < .001$, $\eta_p^2 = .39$), but Level of functioning was not significant (F(1, 56) = 1.4, $p = .25$, $\eta_p^2 = .024$). Importantly the four-way interaction was significant (F(1, 56) = 4.1, $p = .048$, $\eta_p^2 = .068$).

The significant four-way interaction factor allowed to perform two separate 2x2x2 ANOVAs, one for the AS group and their the high-functioning control group, and one for the Autism group and the low-functioning control group. The within-subject factors in both analyses were again Task (Conceptualisation vs. Reconceptualisation) and Endobject (animate vs. inanimate).

Asperger group and controls.

In this analysis the between-subjects factor was Group (AS vs. Control-HF). The 2x2x2 ANOVA showed a highly significant main effect of End-object ($F(1, 28) = 117.4$, $p < .001$, $\eta_p^2 = .81$), reflecting that the images of animate objects were easier to identify than those of inanimate objects; on average 4.3 (SD = 1.6) images for the animate objects and 5.6 (SD = 1.2) images for the inanimate objects were required. The main effect for Group was also significant ($F(1, 28) = 27.5$, $p < .001$, $\eta_p^2 = .50$), with the AS group requiring more frames than the control group. The main effect for Task ($F(1, 28) = 8.28$, $p = .008$, $\eta_p^2 = .23$) was significant, reflecting that more frames were required to correctly identify the objects in the Conceptualisation Task than in the Reconceptualisation Task.

Of the two-way interactions, the Task by Group interaction ($F(1, 28) = 6.9$, $p = .014$, $\eta_p^2 = .20$) and the Endobject by Group interaction ($F(1, 28) = 12.5$, $p < .001$, $\eta_p^2 = .52$) were significant. The Task by Endobject interaction was non-significant ($F(1, 28) = 3.12$, $p = .088$, $\eta_p^2 = .10$). Importantly, the 3-way interaction factor was non-significant ($F(1, 28) = 0.00$, $p = .99$, $\eta_p^2 = .000$). Thus, the reduction in animate advantage - defined as the number of frames required to identify inanimate objects minus the number of frames required to identify animate objects - in the AS group as compared to the control group was equal in both tasks, i.e. it was not affected by the additional requirement to trade in one concept for another.

Next we examined the two-way Endobject x Group interaction in more detail for each group separately.

Conceptualisation Task.

There were significant main effects of Endobject (F(1, 28) = 121.7, p < .001, η_p^2 = .81) and Group (F(1, 28) = 15.1, p = .001, η_p^2 = .35), and the Endobject x Group interaction was significant (F(1, 28) = 24.2, p < .001, η_p^2 = .46). Both the Control-HF and AS groups required significantly more frames to identify inanimate objects than animate objects (Control-HF: t(14) = 11.8, p< .001; AS: (t(14) = 4.1, p = .001). The AS group required significantly more frames to identify animate objects than the control group (t(28) = 5.5, p< .001), but the groups did not differ with respect to the inanimate objects (t(28) = 1.8, p = .076).

Reconceptualisation Task.

As for the Conceptualisation Task, there were significant main effects of Endobject (F(1, 28) = 42.6, p < .001, η_p^2 = .60) and Group (F(1, 28) = 23.1, p <.001, η_p^2 = .54), and the Endobject x Group interaction was significant (F(1, 28) = 14.5, p = .001, η_p^2 = .34). The Control-HF group required significantly more frames to identify inanimate objects than animate objects (t(14) = 6.4, p< .001); for the AS group the difference in frames was only just significant (t(14) = 2.3, p = .037). The AS group required significantly more frames to identify animate objects than the control group (t(28) = 6.3, p< .001), and also required significantly more frames to identify inanimate objects than the control group (t(28) = 3.8, p = .001).

The ‘animate advantage’ did not differ between the two tasks for the Control-HF group (t(14) = 1.2, p = .24) nor for the AS group (t(14) = 1.2, p = .25).

Autism group and controls

In this 2x2x2 ANOVA, the levels of the between-subjects factor Group were formed by the Autism group and the Control-LF group. The main effect for Task was non-significant (F(1, 28) = .243, p = .63, η_p^2 = .009), reflecting that the number of frames required to correctly identify the objects in the Conceptualisation Task did not differ from that in the Reconceptualisation Task. However, as for the above 2x2x2 ANOVA, the use of two different sets of objects in the two tasks rendered this factor meaningless. The main effect of End-object was again highly significant ($F(1, 28) = 101.6$, $p < .001$, $\eta_p^2 = .78$), reflecting that the images of animate objects (M = 4.8, SD = 1.4) were easier to identify than those of inanimate objects (M = 5.8, SD = 1.1). The main effect for Group was significant ($F(1, 28) = 9.1$, $p = .005$, $\eta_p^2 = .25$).

Of the two-way interactions, the Task by Group interaction ($F(1, 28) = 3.3$, $p = .081$, $\eta_p^2 = .105$) and the Endobject by Group interaction ($F(1, 28) = 75.9$, $p < .001$, $\eta_p^2 = .73$) were significant. The Task by Endobject interaction was significant ($F(1, 28) = 17.7$, $p < .001$, $\eta_p^2 = .39$). Importantly, the 3-way interaction factor was significant ($F(1, 28) = 6.2$, $p = .019$, $\eta_p^2 = .18$). This meant that, in contrast to the AS group, the additional requirement to trade in one concept for another (Reconceptualisation Task) did affect the performance of the Autism group. For them it reversed the balance between recognition of animate and inanimate objects in favour of inanimate objects *(see Figure 4.3d).*

We examined the significant three-way interaction further in 2x2 ANOVAs, separately for each task:

Conceptualisation Task

The main effects of Endobject was significant ($F(1, 28) = 117.9$, $p < .001$, $\eta_p^2 = .81$), while the main effect of Group was non-significant ($F(1, 28) = 2.9$, $p = .101$, $\eta_p^2 = .093$). The Endobject x Group interaction was significant ($F(1, 28) = 15.3$, $p < .001$, $\eta_p^2 = .35$). Both the Control-LF and Autism groups required significantly more frames to identify inanimate objects than animate objects (Control-LF: $t(14) = 9.7$, $p < .001$; Autism: ($t(14) = 5.3$, $p < .001$). The Control-LF group required significantly less frames to identify animate objects than the Autism group ($t(28) = 3.1$, $p = .004$), but the groups did not differ with respect to the identification of inanimate objects ($t(28) = .13$, $p = .90$).

Reconceptualisation Task

There was a significant main effect of Endobject (*F*(1, 28) = 7.2, *p* =.012, η_p^2 = .205) and of Group (*F*(1, 28) = 16.2, *p* < .001, η_p^2 = .37), while the Endobject x Group interaction was highly significant (*F*(1, 28) = 44.6, *p* < .001, η_p^2 = .61). The Control-LF group required significantly more frames to identify inanimate objects than animate objects (*t*(14) = 9.7, *p*< .001). For the Autism group the reverse was found, significantly more frames were needed to identify animate objects than inanimate objects (*t*(14) = 2.3, *p* = .039). The Control-LF group required significantly less frames to identify animate objects than the Autism group (*t*(28) = 7.7, *p*< .001), but with respect to the inanimate objects the groups did not differ (*t*(28) = .16, *p* = .88).

For the Control-LF group, the 'animate advantage' did not differ between the two tasks (t(14) = 1.6, *p* = .13), while it did differ significantly for the Autism group (*t*(14) = 4.0, *p* = .001), reflecting that the 'animate advantage' in the Conceptualisation Task had reversed into an 'inanimate advantage' in the Reconceptualisation Task.

IQ

To rule out intelligence as a potential variable, an analysis of covariance (ANCOVA) was performed between Groups (Autism, AS, LF and HF Controls), Endobject (Animate vs Inanimate) and IQ (Verbal and Perceptual). In the Conceptualisation Task, no significant difference was found between endobject and verbal (*F*(1, 54) = .554*, p = .460,* η_p^2 *= .010)* or perceptual (*F*(1, 43) = 1.28*, p = .268,* η_p^2 *= .023)* intelligence. Similarly, in the Reconceptualisation Task, no significant difference was found between endobject and verbal (*F*(1, 54) = 1.58*, p = .215,* η_p^2 *= .028)* or perceptual (*F*(1, 54) = .687*, p = .411,* η_p^2 *= .013)*

Summary

In summary, in both tasks the clinical groups (AS and Autism) required more frames to correctly identify the objects than the control groups. However, the two clinical groups differed from each other in the Reconceptualisation Task with respect to animate objects. That is, the additional requirement to trade in one concept for another in the ReconceptualisationTask, specifically hampered the Autism group in their ability to recognise animate objects.

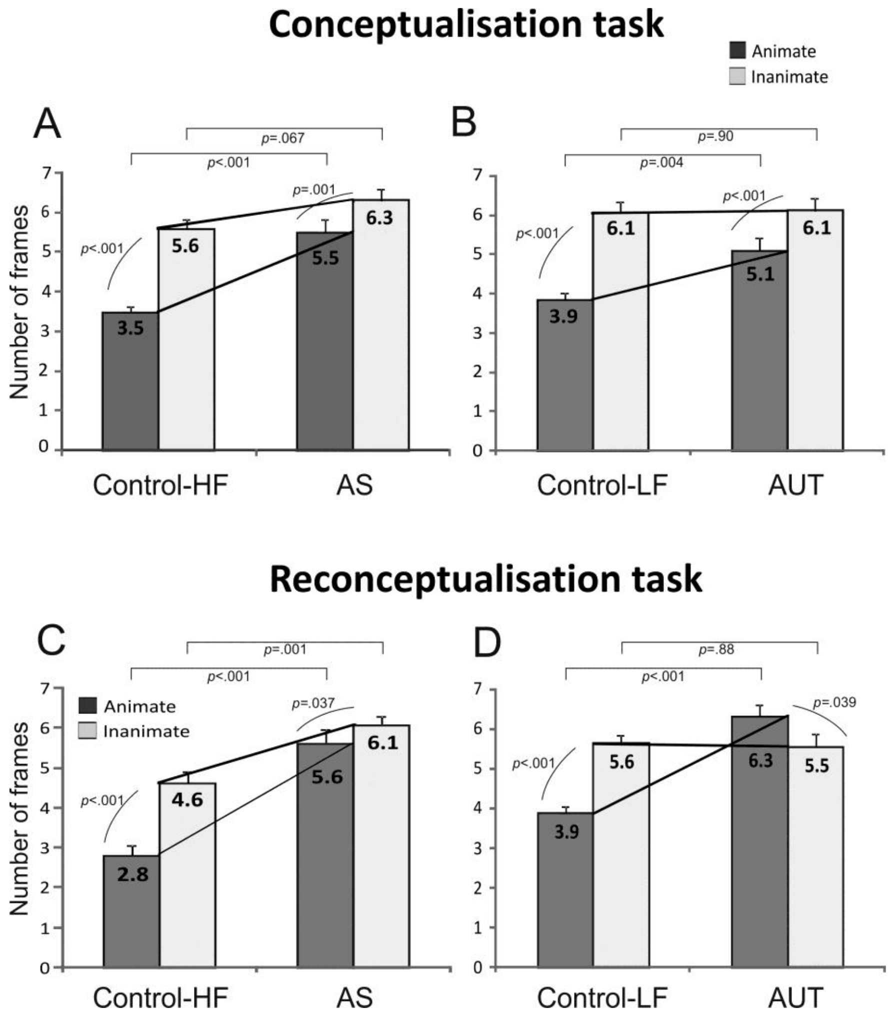

Figure 4.3. The results on the Conceptualisation task and Reconceptualisation Tasks, for the AS group (left panel) and Autism group (right panel), along with their control groups. The mean numbers of images required to correctly identify the objects is shown (y axis).

Did the presence or absence of a switch in category between start- and end-object affect the recognition of the end-object?

In the Reconceptualisation Task, we further looked whether there was an interaction between the animate or inanimate nature of the start- and endobjects. In particular, we wanted to know whether a switch between categories (from animate to inanimate or vice versa) had more adversary effect on recognition of the new object than a switch between different objects belonging to the same category (e.g. a switch from one animal into another animal). Here two, 2x2 ANOVAs in which the within-subject factors were the Start- and End-object (both animate or inanimate) were performed for each group to determine the Start object by Endobject interactions. The following interaction factors were found: AS group, $F(1, 14) = .24$, $p = .63$, $\eta_p^2 = .017$; Control-HF group, $F(1, 15) = 2.1$, $p = .17$, $\eta_p^2 = .12$; Autism group, $F(1, 14) = 12.2$, $p = .004$, $\eta_p^2 = .47$; Control-LF group, $F(1, 14) = 2.0$, $p = .18$, $\eta_p^2 = .12$. Only the Autism group showed a significant Startobject X Endobject interaction. Closer inspection of this interaction revealed that it was due to animate end-objects being recognised better when the start-object was also animate, as compared to inanimate ($t(14) = 3.03$, $p = .009$; animate/animate sequence, M = 5.9, SD = 1.1, inanimate/animate sequence, M = 6.7, SD = 1.3). The recognition of inanimate end-objects was not affected by the nature of the start-object ($t(14) = 1.6$, $p = .14$).

Incorrect guesses

Incorrect guesses had been recorded to be able to determine whether any differences existed between the groups in absolute number of guesses made, and/or whether any differences existed in the relative numbers of animate and inanimate guesses. As the Autism group performed differently to the other three groups in the Reconceptualisation Task, showing an advantage for inanimate objects over animate objects, a comparison of all guesses was performed on the Autism and Control -LF groups.

Surprisingly perhaps, the Autism group made significantly more guesses (before the correct response was given) than the Control-LF group ($t(54) = 2.8$, $p < .008$). The mean number of guesses was .041 in the Autism group and .025 in the Control-LF group. Of these guesses, 58.5% were animate in the Autism group and 65.3% were animate in the Control-LF group. These percentages of Animate responses did not differ from each other ($t(50) = .68$, $p = .50$) *(see Figure 4.4).*

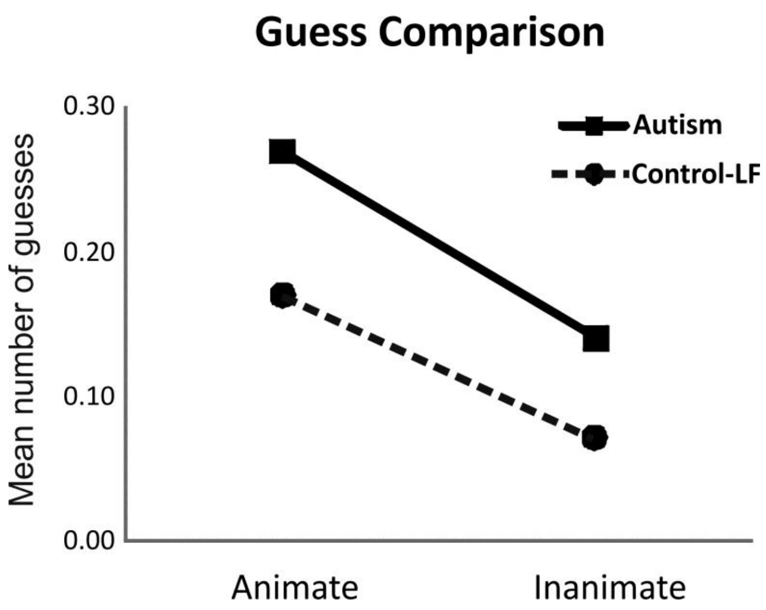

Figure 4.4. Guesses made before the correct response was given. Mean number of guesses (animate and inanimate) made by the Autism group and the low-functioning control group in the Reconceptualisation Task.

Discussion

The ability to form new concepts from scratch (experiment 1: Conceptualisation Task), and to flexibly switch from one concept to another involving disengagement from a concept (experiment 2: Reconceptualisation Task), was investigated in children diagnosed with ASD and typically developed children, did not differ significantly in cognitive ability, age and sex.

We further investigated if the animate vs. inanimate nature of these objects affected the conceptualisation and reconceptualisation abilities.

A main hypothesis was that the two tasks measured different abilities, i.e. to conceptualise versus to reconceptualise, and that the clinical groups would be especially hampered in the ability to reconceptualise. We indeed found that the number of frames required to correctly identify the objects was significantly increased in the Autism group, but only for animate endobjects! The AS group turned out not to be affected by the requirement to reconceptualise.

A factor that might have affected the difference in number of frames required to correctly identify the object in the two tasks may have been that in the Reconceptualisation Task some information about the end-object was already present before the 50%A/50%B object. In the Conceptualisation Task the sequence started from the 50%A/50%B object and such prior information was thus absent. This could have allowed the participant to generate ideas about the nature of the object already before the 50%A/50%B image appeared. It should be noted that participants were not allowed to verbalise any guesses before the middle frame (50%A/50%B) was presented.

Overall, the images of animate objects were easier to identify than those of inanimate objects. It is possible that this 'animate advantage' could have been due to the animate objects being inherently easier to recognise (possibly more familiar) than the inanimate ones, but it could also be due to an underlying 'processing benefit' for animate objects. In the Conceptualisation Task, the ASD and control groups both showed an 'animate advantage'. However, in the Reconceptualisation Task, the Autism group lost this 'animate advantage' and showed instead an advantage for inanimate objects. This was a quite surprising finding.

The main findings with respect to the AS group were that, first of all, this group required more frames to correctly identify the objects than the control group, in both the Conceptualisation and Reconceptualisation Task. The second finding was that, again in both tasks, the AS group showed an 'animate advantage', which was, however, much smaller than the 'animate advantage' in their control group. For the Autism group, the main findings were that they, similarly to the AS group, more frames were required to correctly identify the objects as compared to the control group, in both tasks. However, they differed from the AS group with respect to the ‘animate advantage’ in the Reconceptualisation Task. On the Conceptualisation Task they showed a reduction in ‘animate advantage’ compared to the control group, similarly to what was found for the AS group, but on the Reconceptualisation Taskthe ‘animate advantage’ reversed into an ‘inanimate advantage’. The important conclusion is that the Autism group, in contrast to the AS group, was affected by the additional requirement to reconceptualise.

What could be the underlying mechanism?

We argue that the Autism group, but not the other groups, possessed an underlying processing deficiency specifically for animate objects, and that this deficiency surfaced due to the added complexity of trading in an existing concept for a new one (Reconceptualisation Task). That is, the cognitive switching which had to be performed took up attentional resources and thereby exposed the slumbering deficiency in animate processing. It resulted in a reversal of their ‘animate advantage’ in the Conceptualisation Task into an ‘inanimate advantage’ in the Reconceptualisation Task. However, alternative explanations for why the Autism group lost the advantage for animate objects in the Reconceptualisation Task may exist. These will be assessed next (*see also discussion in Chapter 3*):

(i) It has been suggested that autistic children without developmental delay (i.e. AS) make less spontaneous interpretations of ambiguous figures (Sobel, Capps & Gopnik, 2005). In principle, making less guesses of an animate nature would reduce the chances of making correct identifications of animate objects, which could explain the impaired recognition of animate objects. However, we found that in the current experiment the Autism group generated significantly more animate and inanimate guesses than the control group. In fact, the Autism group showed an advantage for identifying inanimate objects in the

Reconceptualisation Task, even though 58.5% of overall guesses made were animate. The Autism group made significantly more animate guesses than the control group, suggesting that the impaired recognition of animate objects cannot be explained by making less animate guesses (and therefore reducing the chance of making a correct guess). This shows that the Autism group were not poorer at identifying animate objects because they were poorer at generating animate guesses. Possibly, the difficulty in identifying animate objects in the Reconceptualisation Task was compensated with the generation of many guesses. One could postulate that this was an attempt to mask an impairment in identifying animate objects.

(ii) Another possibility is that the animate objects were easier to identify due to characteristics in their shape. However, the animate objects did not differ in compactness nor homogeneity to the inanimate objects *(see Chapter 3),* suggesting that the animate objects were equally complex as the inanimate ones.

(iii) It could be that in particular the animate objects contained reduced local detail. Autistic individuals have been shown to be poor at tasks involving objects presented with merely global information (Happe & Frith, 2006). However, as there was no significant difference in the complexity of the animate and inanimate shapes, and the objects contained no inner detail or colour (as they were silhouette), it is unlikely that this hampered the ability to identify animate objects.

A Deficit in Processing Animate Objects in ASD

It was quite remarkable that on both tasks, the ASD groups (AS and Autism) were significantly poorer at identifying animate objects than the controls, while for inanimate objects they were only slightly poorer or equally good. Several studies suggests that children with autism encode animate objects, such as faces, abnormally (Davies et al., 1994; Langdell, 1978). Autistic children have also been found to be impaired in recognising familiar animate stimuli, such as faces, voices (Boucher et al., 1998) and actions (Bowler & Thommen, 2000).

In tasks of cognitive flexibility, which involve processing multiple cues, adults and adolescents with ASD have been shown to be compromised (Kleinhans, Akshoomoff & Delis, 2005). Specifically, individuals with ASD have being found to have impairments in attention related to deficits in social functioning (e.g., Courchesne et al., 1994). It could be that the autistic individuals' disadvantage in comparison to typical children for recognising animate objects in the Reconceptualisation Task was due to the increased difficulty of multiple, unpredictable animate stimuli presented simultaneously. The fact that there was no significant difference compared to the control group in identifying animate objects could suggest that the deficit in autism lies not in switching attention, but in the nature of the stimuli processed.

Summary

In summary, Dawson and Lewy (1989) proposed that children with autism do possess a general impairment in orienting and switching attention, but these impairments are more evident for animate than for inanimate stimuli. They argue that children with autism have problems with processing complex and unpredictable social stimuli, such as facial expressions, speech, gestures and therefore their attention is not naturally drawn to animacy. This processing deficit is argued to be due to an impairment in arousal modulation (Pierce, Gland and & Schreibman, 1997), which influences their capacity to attend to social or animate information. Complex social situations cause an autistic individual to become over-aroused, as a result of which they fail to maintain attention to the stimulus. In accordance with these ideas, (Pierce et al.,1997) found that children with ASD had no deficits in general attention tasks and social perception tasks involving identifying one social cue. However, the children with autism performed more poorly than comparison groups on social perception questions relating to stories containing multiple cues. The findings of the current study and of the study presented in Chapter (Burnett & Jellema, 2012) support an attentional deficit in autism. It is possible, however, that attentional dysfunction does not manifests as a general deficit in autism, as children with ASD were not impaired in recognising inanimate objects. Instead it could be postulated that the underlying deficit is, more specifically an impairment in attention to complex and unpredictable animate stimuli.

CHAPTER 6. A modification of the D-KEFS Sorting Task: Concept Formation Versus Switching, in Individuals with and without Autism Spectrum Disorders, "The inescapability of physical reality"

Abstract

A modification of the D-KEFS sorting task was used to investigate factors that influence the abilities to form new concepts and to flexibly switch from one concept to another, in individuals diagnosed with Autism Spectrum Disorder (ASD) and typically developing individuals (TD) that did not differ in cognitive ability, sex and age. In the standard version of the D-KEFS sorting task, the experimenter shuffles the cards after the participant made a particular card sort, so that any new sort the participant may make is made 'from scratch'. The shuffling presumably aids the participant in disengaging from the selected concept before identifying a new one. Still, individuals with ASD tend to perform worse on this task than the TD groups. In our modified D-KEFS sorting task, the 'shuffle' phase was removed. Thus, while the participant attempted to make a new sort, the cards remained physically arranged as in the previous sort. We hypothesised that this modification would further compromise the ability to form new concepts in the ASD group, as compared to the original 'shuffle' version. We further hypothesised that the no-shuffle modification would not affect the TD group. Three ASD groups were tested: adult individuals with Asperger's syndrome (AS), children with AS, and children with autism.

The ASD groups performed similarly to the controls in the shuffle condition, but were impaired in generating new card sorts when no shuffle was made. The results suggests that individuals with autism are particularly sensitive to, and influenced by, the physical presence of a particular arrangement of objects, to such an extent that it hampers their ability to switch to a new arrangement or concept.

Introduction

Cognitive flexibility is crucial in social interaction. It allows an individual to flexibly shift thoughts or actions depending on situational demands (e.g. Geurts, Corbett & Solomon, 2009). Evidence suggests that a majority of individuals with Autism Spectrum Disorders (ASD) have social-cognitive impairments, including deficits in cognitive flexibility (e.g.Kaland, Smith & Mortensen, 2008). It is often argued that deficits in executive functions, such as attention switching, may render a child unable to respond to e.g. an environmental stimulus (e.g. an unexpected noise; Rimland, 1964) and therefore may hamper social interaction.

Executive functions such as concept formation and concept switching are typically investigated simultaneously (e.g. Delis, Kaplan & Kramer, 2001). However, the two functions may be considered as separate cognitive abilities; concept formation referring to identifying a new concept from scratch and concept switching referring to identifying a new concept whilst disengaging attention from another (cf. Courchesne et al., 1994). It is therefore important to disentangle them in studies, especially those in which multiple stimuli are presented.

It has been documented that there is an impairment in quickly shifting attention from one stimulus to another in ASD (e.g. Rhinehart et al., 2001). Several studies support the presence of attentional deficits in ASD, such as studies revealing a general deficit in focused attention (Kaland et al., 2008), in joint attention (Charman et al., 1997) and disengaging attention (Hughes & Russell, 1993). Individuals with autism have been found to remain fixated on the first stimulus, when presented with several stimuli (Hughes & Russel, 1993) and make less eye movements between stimuli (Swettenham et al., 1998). Predominantly research on attentional flexibility has focused on low-functioning autism, and not so much on high functioning autism (HFA) or AS. It has been suggested that individuals with HFA may suffer from attention switching deficits too, but to a lesser extent than those with severe forms of autism (Kleinhans, Akshoomoff & Delis, 2005).

Executive Functioning and ASD

The Executive functioning theory postulates that individuals with ASD can direct their attention more successfully to detail and show an advantage for processing local rather than global information (e.g. Plaisted, Swettenham & Rees, 1999; Happé & Frith, 2006). Executive functioning is used to describe abilities such as planning, working memory, impulse control, inhibition and cognitive flexibility (Ozonoff & Jensen, 1999; Hill & Bird, 2006). Children with autism have shown impairments in tasks demonstrating planning (e.g. Tower of Hanoi; Hughes, Russell & Robbins, 1994) and mental flexibility (Wisconsin Card Sorting Task; Ozonoff, Pennington & Rogers, 1991).

It is hypothesised that cognitive flexibility and attention switching the pre-frontal cortex (Baddeley & Wilson, 1988; Miller & Cohen, 2002). Neuroimaging studies investigating the coordination of attention, arousal and motor control imply a role of the cerebellum (Courchesne, 1987, 1989; Courchesne et al., 1988). Deficits in the cerebellum in autism form a consistent feature that may render the child unable to adjust mental focus and signal changes. Interestingly, autistic patients have been found to perform similarly to cerebellar damaged patients in attention switching tasks (Courchesne et al., 1994). Executive deficits may explain how an autistic child may fail to develop a theory of mind, as they cannot ‘disengage from the salience of physical reality’ (Hughes & Russell, 1993). That is, they cannot form a new concept whilst having to disengage their attention from another that is physically present. Children with autism have shown impairments in tasks demonstrating planning (e.g. Tower of Hanoi; Shallice, 1982), mental flexibility (Wisconsin Card Sorting Task, Milner, 1964) and verbal fluency (Verbal Fluency Test; Perret, 1974)

Delis Kaplan Executive Functioning System (D-KEFS)

Autistic individuals have been found to perform significantly below average in Delis Kaplan Executive Functioning tasks (D-KEFS), particularly when switching and inhibition are required, such as in the Colour-Word Inference Test, Trail Making Test, Verbal Fluency Test and Design Fluency Test (Kleinhans et al., 2005). Another component of the D-KEFS is the Sorting Task, which is based on the Wisconsin Card Sorting Task (WCST; Milner, 1964). The WCST has shown profound deficits in forming and switching concepts in autism (Landy & Bryson, 2004). In the card sorting task an individual is required to abandon one previously correct strategy for sorting the cards, e.g. shape, and change to a new sorting strategy, e.g. colour. The WCST assesses abstract concept formation and switching skills in response to changing conceptual rules. Significant impairments in the formation of sorts in the WCST has been found in low functioning adults with autism (Rumsey, 1985) and a similar effect was also found in children with ASD (Minshew, Meyer & Goldstein, 2002; Van Eylen et al., 2011).

The D-KEFS Sorting Task incorporates a number of new design features in the sorting procedure, such as the cards displaying both perceptual stimuli and printed words, which enables the participant to use both verbal and non-verbal strategies to sort the cards. So far the D-KEFS has not been substantially researched in ASD, however, it is hypothesised that similar results to the WCST would be found as both tasks involve a similar procedure.

Central Coherence and ASD

The weak central coherence theory postulates that an individual may fail in executive tasks because they fail to pull together several strands of information in order to process a higher level meaning (Hill & Frith, 2003). The cognitive deficits reported in autism have been argued to be largely a difference in cognitive processing style (Happé, 1999). Autistic individuals have been shown to be better than typical subjects at searching for a part of an object in tasks such as the Embedded Figure Task (Shah & Frith, 1983) and on a subset of the Wechsler intelligence scale, the Block Design Task (Shah & Frith, 1993). This supports the theory that individuals with ASD focus on details at the expense of global contextual understanding and therefore have weak central coherence (Frith 1989). They would therefore, potentially, show an advantage in a version of the WCST because they can elicit local details about parts of objects (Happé, 1999) and identify patterns and sequences (Shah & Frith, 1993) more efficiently than typical individuals. However, previous research indicates that a failure in this task may indicate an executive functioning deficit, mainly in concept formation and cognitive flexibility (e.g. Rumsey, 1985).

Interestingly, some tasks involving modifications to the procedure of executive functioning tasks show that individuals with autism can perform similarly to controls (e.g. Russell, Jarrold & Hood, 1999). Ozonoff (1995) found that an ASD group performed better on a computerized version of the WCST than in the standard format. This computerised version did not require any social or verbal demands and therefore is argued to measure executive functioning in autism more effectively. This was also found in children with high functioning autism, who made less correct card sorts and more errors in the traditional WCST, than in the computerized version (Tsuchiya et al., Fujieda, 2005). Van Eylen et al. (2011) also propose that performance of children with ASD is related to social demands and the degree of disengagement required to perform the switch.

It is therefore important to further investigate any factors that may affect the specific executive skills of concept formation and concept switching, and which factors may influence the differences that are found between typical individuals and those with ASD, on cognitive flexibility tests.

The Current Study

The goal of the current study was to investigate factors that influence the abilities to form new concepts and to flexibly switch from one concept to another, in individuals diagnosed with Autism Spectrum Disorder (ASD) and typically developing individuals, using a modification of the D-KEFS sorting task. The standard version of the D-KEFS sorting task involves the experimenter shuffling the cards after the participant made a particular card sort, so that any new sort the participant may make is made ‘from scratch’ (shuffle condition). In our modified D-KEFS sorting task, the ‘shuffle’ phase was removed (no shuffle condition). Thus, while the participant attempted to make a new sort, the cards remained physically arranged as in the previous sort. The group of adults were university students, diagnosed with AS. The children with ASD were divided into two groups, depending on the severity of autistic symptoms (autism and Asperger’s syndrome). For each clinical group controls groups were used, that did not differ in chronological age, sex, and verbal and non-verbal cognitive ability.

A first aim was to determine whether an established executive functioning task (D-KEFS Sorting Task), designed to measure cognitive flexibility, can be used in a unique way to differentiate the abilities of concept forming and concept switching. That is, are individuals with ASD hampered in concept formation when they have to visually disengage from a previously formed concept?

A second aim was to investigate possible differences between groups differing in severity of autistic traits. If significant differences would be found between the AS and autism groups than that would support the notion of a cognitive flexibility dimension underlying the autism spectrum.

Method

Participants

Clinical groups

The clinical group consisted of twenty children and twenty-two adults recruited through child and adolescent mental health services (CAMHS) and universities and schools in the North-East of England (UK). All these participants had previously received a diagnosis of Autism or Asperger’s Syndrome, based on DSM-IV criteria (APA, 2000). These diagnostic evaluations involved a review of prior psychology records/psychiatric observation and the ADOS (Autism

Diagnostic Observation Schedule, module 3 or 4: Lord et al., 1999). Adult participants completed the AQ (Baron-Cohen et al., 2001) and parents of children completed the Adolescent AQ 11-15 years (Baron-Cohen, Knickmeyer & Wheelwright, 2006) about their child, which were used as an additional screening tool and as exclusion criterion.

All the adults in this study had a diagnosis of AS, they were university students with an IQ within the average range or above, when assessed using the Wechsler Adult Intelligence Scale, WAIS III (Wechler, 1997); *see Table 6.1* for participant characteristics. They did not have any language difficulties and did not vary significantly in verbal or non-verbal ability. However, the individual children varied quite widely in the severity of autistic symptoms, as well as in their overall intellectual ability. Therefore the children were separated into groups based on the ADOS criteria for either autism or AS. For the group of children who met the criteria for Autism, cognitive functioning was well below average assessed with the Wechsler Intelligence Scale for Children, WISC-III, Wechsler, 1991). For the group of children who met the criteria for AS, cognitive functioning was within the average range (assessed using the Cognitive Ability Tests CAT-3, Lothman, Hagen & Thorndike, 1995). Thus there were in total three distinct clinical groups: (1) Adults with AS, (2) Children with AS and (3) children with Autism.

(1) Adult Asperger's Group

The participants were a subset of those from the Silhouette (Re-)Conceptualisation study. Three participants were excluded for having ADOS scores lower than 7 (scores of 4, 5 and 6). The nineteen remaining participants that were included in the analysis (13 males, 6 females; mean age = 21.2 years, SD = 6.1) had a mean total ADOS score of 8.0 (SD = 0.94). Their mean IQ score was 118 (SD = 9.7; assessed using the WAIS-III), and their mean AQ score was 29.95 (SD = 8.3*) (see Table 6.1).* The adults conformed to criteria for AS, as they all had impaired social communication and relating skills and repetitive behaviours of various kinds but no language deficits (cf. Asperger, 1944).

(2) Children Asperger's Group

After excluding four children from the analysis due to incompletion of tasks, this group consisted of ten children (9 males, 1 females; mean age = 13.4 years, SD = 1.0), with a mean total ADOS score of 8.1 (SD = 0.9). Their mean cognitive ability score was 96.6 (SD = 13.1), assessed using the CAT-3, and their mean AQ score was 37.8 (SD = 3.7) *(see Table 6.1).* Similarly to the adult group, the children conformed to criteria for Asperger's Syndrome, as they all had impaired social communication and relating skills and repetitive behaviours of various kinds but no language deficits

(3) Children Autism Group

After excluding three children from the analysis due to incompletion of tasks, this group consisted of ten children (9 males, 1 females; mean age = 14 years, SD = 2.3), with a mean total ADOS score of 14.2 (SD = 5.2). Their mean IQ score was 70.3 (SD = 8.5) assessed using the WISC-III, and their mean AQ score was 28.9 (SD = 10.6*) (see Table 6.1).* The children conformed to criteria for the diagnosis of autism (Rutter, 1978). All had impaired language ability and communication skills, impaired social relating skills and repetitive behaviours of various kinds.

Control groups

Nineteen TD adults, 11 TD high-functioning children, and 10 children with low cognitive ability (learning disabilities) did not differ in chronological age, sex and overall (verbal and non-verbal) cognitive ability to the three clinical groups (using the same appropriate cognitive measures as the clinical groups). The adult controls were all students at Hull University, they were a subset of those from the Silhouette (Re-)Conceptualisation study. The high-functioning children were recruited through typical schools, and the low-functioning children through special needs schools, both in the North-East of England (UK).

Adult participants completed the AQ and parents of children were asked to complete the Adolescent AQ (Ad-AQ) 11-15 years about their child, as a screening tool for autistic traits and as a possible exclusion criterion. All children who were recruited from special needs schools additionally completed an ADOS as an additional exclusion criterion. Incompletion of task resulted in eight children being excluded from analysis (six from the high-functioning group, two from the low-functioning group). The cognitive ability for children from special needs schools was assessed using the WISC-III. The high-functioning children were recruited from typical schools and their cognitive ability was assessed using the CAT-3 and adults completed a WAIS-III (*see Chapter 2)*.

(1) Adult Control Group

After excluding two adults from the analysis due to incompletion of tasks, this group consisted of nineteen participants. Of the nineteen adults (11 males, 8 females; mean age = 20.5 years, SD = 3.2), thirteen were tested using the WAIS-III, their mean total was 116.7 (SD = 6.2). The mean AQ score was 12.5 (SD = 5.5) *(see Table 6.1).*

(2) Children High-functioning Control Group

After excluding six children from the analysis due to incompletion of tasks, this group consisted of ten children (7 males, 3 females; mean age = 13.0 years, SD = 1.2). They had a mean IQ score of 107.5 (SD = 8.0), assessed using the CAT-3, while their mean AQ score was 12.3 (SD = 4.5) *(see Table 6.1).*

(3) Children Low Functioning Control Group

After excluding two children from the analysis due to incompletion of tasks, this group consisted of ten children (7 males, 3 females; mean age = 14.5 years, SD = 1.1) who had a mean total ADOS score of 2.0 (SD =1.7). Their mean IQ score was 71.7 (SD = 12.7), assessed using the WISC-III, while their mean AQ score was 21.1 (SD = 3.7) *(see Table 6.1).*

All control and ASD participants had normal or corrected-to-normal vision, and provided (parental) written consent prior to the experiment. Participants participated voluntarily in the study. The study was approved by the Ethics Committee of the Department of Psychology, Hull University.

GROUP			n	Age	Sex	AQ	Cognitive Test	T	V	P	ADOS
ADULTS	HF	Asperger's	19	21.2 (6.1)	13 M, 6 F	29.95 (8.3)	WAIS-III	117 (9.8)	119.8 (14.2)	113.2 (14.9)	8.0 (0.94)
		Control	19	20.5 (3.2)	11 M, 8 F	12.5 (5.5)	WAIS-III	112.6 (8.8)	113.5 (7.9)	110.3 (12.2)	
CHILDREN	HF	Asperger's	10	13.4 (1.0)	9 M, 1 F	37.8 (3.7)	CATS-III	96.6 (13.1)	95.9 (11.6)	96.0 (13.3)	8.1 (0.9)
		Control	10	13.0 (1.2)	7 M, 3 F	12.3 (4.5)	CATS-III	107.5 (8.0)	106.6 (12.1)	108.4 (13.3)	2.0 (1.7)
	LF	Autism	10	70.3 (8.5)	9 M, 1 F	28.9 (10.6)	WISC-III	70.3 (8.5)	73.7 (11.6)	74.1 (12.4)	14.2 (5.2)
		Control	10	14.5 (1.1)	7 M, 3 F	21.1 (3.7)	WISC-III	71.7 (12.7)	74.8 (15.4)	68.8 (14.3)	

Table 6.1.Participant characteristics.The adult and child high functioning (HF) groups and the child low functioning (LF) group. Age is in years. F, female; M, male. AQ, Autism-Spectrum Quotient. CATS-T, total score, V, verbal score, P, non-verbal-performance score. WISC/WAIS-IQ-T, total IQ score. IQ-P, Performance IQ score. IQ-V, verbal IQ score. Standard deviations are shown between brackets.

Stimuli

For both tasks, objects were selected from the Sorting Task, which forms part of the Delis Kaplan Executive Functioning System (Delis et al. ,2001). There were four card sets in total, each containing six cards *(see Figures 6.1 and 6.2).*

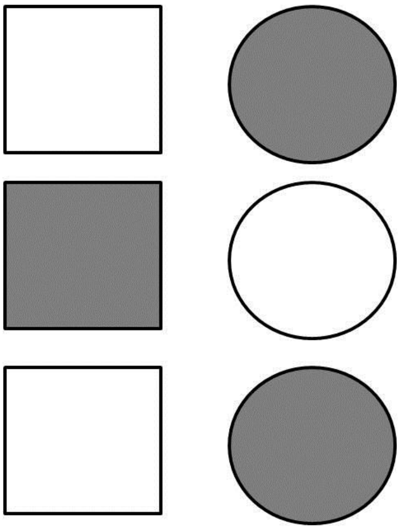

Figure 6.1. Example of practice cards in Sorting Task, where the cards can be sorted into two groups of three depending on the shape or colour.

Procedure

Prior to the experiment, all adult participants (TD and ASD) completed the AQ, and parents of all children completed the child 11-15 years version of the AQ, both questionnaires take around 5 minutes to complete. All adults and children in the ASD groups and children in the low-functioning control group, completed Module 3 or 4 of the ADOS (depending on the individual's chronological age and cognitive ability with the examiner (HB), which takes around between 40-60 minutes to complete (depending on the participants responses). All Adult participants in the AS group and 11 participants from the adult control group completed the WAIS-III. Children in the low functioning groups, who did not have a recent WISC assessment from an Educational Psychologist, were asked to complete WISC-III (taking around 1hr30) at the same time as the ADOS. The children in the high-functioning group, the CAT-3 tests were administered at their school and scores were obtained from their class teacher.

Participants were seated opposite the examiner. All instructions were presented visually via the stimulus book and verbally, throughout the experiment. First, a screening pre-test was administered to verify the participant's language and reading ability, then one practise trial was given, after which the experimenter verified the participant's understanding of the task. The exact duration of the experiment depended on the participant's performance (participants were given a maximum of 4 minutes cumulative sorting time for each card set), but lasted on average 30 minutes, including the screening pre-test and sort recognition task.

The participant was told they could make unlimited sorts, according to what they thought the correct card categories were. They were also told that they must explain their sort to the examiner. The experimenter recorded all descriptions and guesses made by the participant. All participants performed two card sorting tasks in the 'shuffle' condition and two in the 'no shuffle' condition. The shuffle condition involved the examiner reorganising the position of the six cards directly proceeding a correctly made sort by the participant before they made another card sort, and two sorting tasks that involved a no shuffle condition *(see Figure 6.2).* Task condition and card set were both randomized in order for participants in all clinical and control groups.

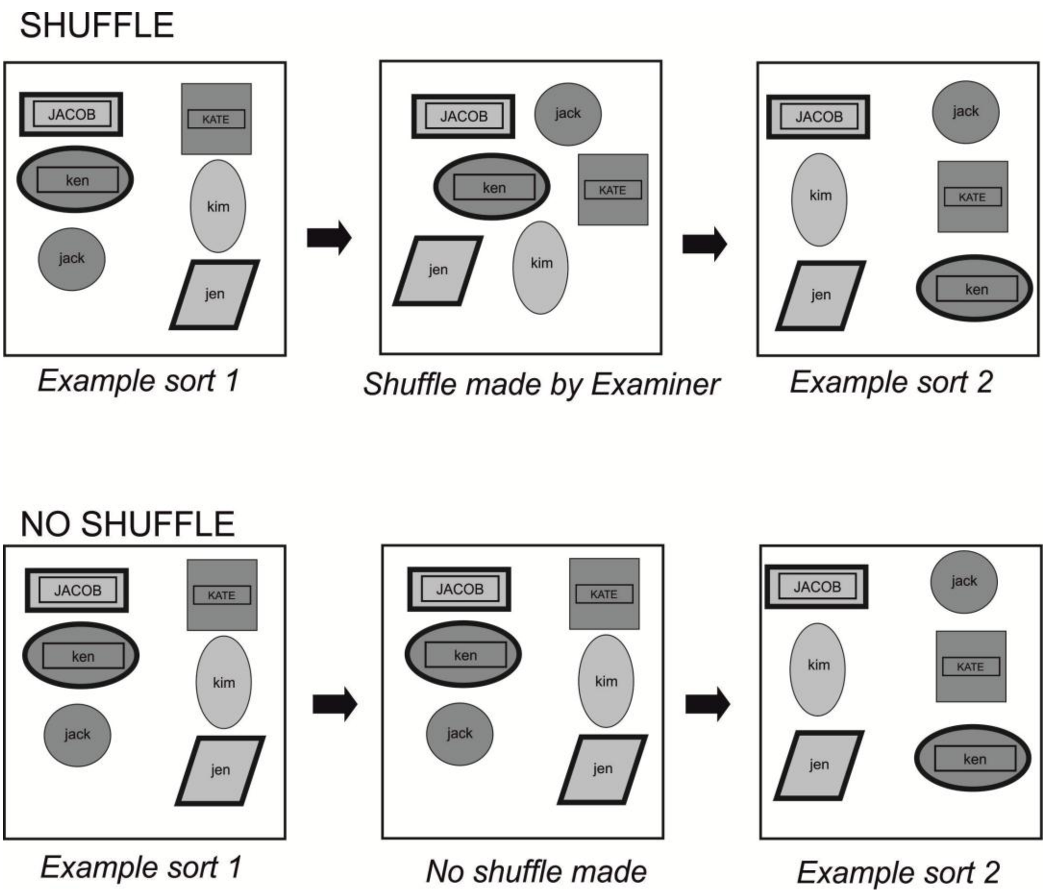

Figure 6.2.Example of procedure; Condition involves either the examiner shuffling the cards after a correct card sort is made (sort 1) or not shuffling the cards, then the participant must make a new correct sort (sort 2).

Task 1: Shuffle

There were two different card set used in this condition, each consisting of six cards. The sets contained different cards but for both a maximum of eight different sorts could be made (four of which were verbal and four perceptual in nature). The cards were presented to the participant simultaneously in a random arrangement on a table, and the participant was instructed to sort the cards physically into two groups, with three cards in each group. On the basis of a particular conceptual classification. The participant was instructed that they must explain in what respect the two subgroups of three cards differed from each other and what made each set of three cards alike. In the shuffle condition (i.e. the standard version of the D-KEFS), participants were instructed that once they had made a sort, they must remove their hands from the table and allow the examiner to shuffle the cards into a random configuration. The participant must then make a different card sort. The number of correct sorts was recorded, as well as the description of the sort given. After completion of both card sets, a recognition task was performed, in which the participant was asked to identify the 16 rules behind the sorts that the examiner performed.

Task 2: No Shuffle

The no-shuffle condition was identical to the shuffle condition, except that participants were instructed, that once they had made a correct sort, they must describe the sort and then go on to try and make a new sort, without the examiner interfering with the position of the cards. Thus, in this condition, the examiner does not rearrange the cards after each sort made by the participant, meaning that the participant will not make a new sort from scratch, but have to mentally disengage from the previous card sort they can still see in front of them.

Results

Initially an overall 2x6 ANOVA was made, in which the within-subject factor was Task (shuffle vs. no shuffle), and the between-subjects factor was Group (AS-adults vs AS-children vs. AUT-children vs. Control-adults vs. Controlchildren HF vs. Control children LF. The dependant variable was the number of different correct sorts a participant made, expressed as Mean Scale Scores. This analysis showed a significant main effect for Task ($F(1, 5) = 14.8$, $p < .001$, $\eta_p^2 = .17$), reflecting that more correct sorts were made in the shuffle condition (Mean Scaled Score, MSS = 10.2, SD = 1.5) than in the no-shuffle condition (MSS = 9.1, SD = 1.4). The factor Group was significant ($F(5, 73) = 25$, p < .001, $\eta_p^2 = .63$) as was the Task by Group interaction factor ($F(5, 73) = 5.0$, p < .001, $\eta_p^2 = .26$).

We next compared each clinical group directly with its own control group in three separate two-way ANOVAs (Task by Group).

(1) Asperger's Adult Group

A 2x2 ANOVA, with Task (shuffle vs. No shuffle) and Group (AS-adults vs controls) as factors, revealed a non significant main effect for Task ($F(1, 37) = 3.8$, $p = .058$, $\eta_p^2 = .094$). No significant effect for Group was found ($F(1, 37) = .85$, $p = .36$, $\eta_p^2 = .022$). However, a significant interaction was found between Task and Group ($F(1, 37) = 5.6$, $p = .023$, $\eta_p^2 = .13$). This interaction was further investigated with separate t-tests. The AS group generated significantly fewer sorts in the No-shuffle condition (MSS = 10.4, SD = 2.2) than in the Shuffle condition (MSS = 12.5, SD = 2.3) ($t(18) = 3.42$, $p = .003$). However, the controls performed equally well in both conditions: Shuffle, (MSS = 10.9, SD = 2.3; No-shuffle, MSS = 11.1, SD = 2.0) ($t(19) = .27$, $p = .80$) *(see Figure 6.3a).*

(2) Asperger's Children Group

The 2x2 ANOVA revealed a significant main effect for Task ($F(1, 18) = 11.85$, $p = .003$, $\eta_p^2 = .397$), reflecting that more correct sorts were made in the shuffle condition (MSS = 10.3, SD = 1.4) than in the no shuffle condition (MSS = 8.5, SD = 2.7). A significant effect for Group was found ($F(1, 18) = 14.52$, $p = .001$, $\eta_p^2 = .446$), reflecting that overall the control group made more correct sorts (MSS = 10.4, SD = 1.7) than the AS group (MSS = 8.4, SD = 2.4). A significant Task by Group interaction was found ($F(1, 18) = 11.85$, $p = .003$, $\eta_p^2 = .397$). To investigate this interaction further, separate t-tests were performed.

As was found in the AS adult group, the AS children group generated significantly fewer sorts in the No-shuffle condition (MSS = 6.6, SD = 1.9) than in the Shuffle condition (MSS = 10.2 , SD = 1.1) ($t(9) = 6.2$, $p < .001$). Again similar to the adult AS group, the controls performed equally well in the shuffle and no-shuffle conditions (Shuffle, MSS = 10.4, SD = 2.3; No-shuffle, MSS = 10.4, SD = 2.0) ($t(9) = 0$, $p = 1.0$) *(see Figure 6.3b).*

(3) Autism Children Group

The 2x2 ANOVA revealed a significant main effect for Task (F(1, 18) = 6.44, p = .021, η_p^2 = .263), reflecting that participants made more correct sorts in the shuffle condition (MSS = 7.2, SD = 2.1) than in the no shuffle condition (MSS = 6.5, SD = 2.4). A significant effect for Group was found (F(1, 18) = 8.46, p = .009, η_p^2 = .320), reflecting that overall the control group (MSS = 8.0, SD = 2.0) made more correct sorts than the AS group (MSS = 5.7, SD = 2.0). A significant interaction was found between Task and Group (F(1, 18) = 18.92, p < .001, η_p^2 = .512). To investigate this interaction further, separate t-tests were performed. Similar to the previous two clinical groups, the Autism children group generated significantly fewer sorts in the No-shuffle condition (MSS = 4.7, SD = 2.1) than in the Shuffle condition (MSS = 6.6 , SD = 2.1) (t(9) = 5.0, p = .001), while also this control group, similar to the previous two control groups, performed equally well in the shuffle and no-shuffle conditions (Shuffle, MSS = 7.7, SD = 2.0; No-shuffle, MSS = 8.2, SD = 2.0) (t(9) = 1.2, p = .24) *(see Figure 6.3c).*

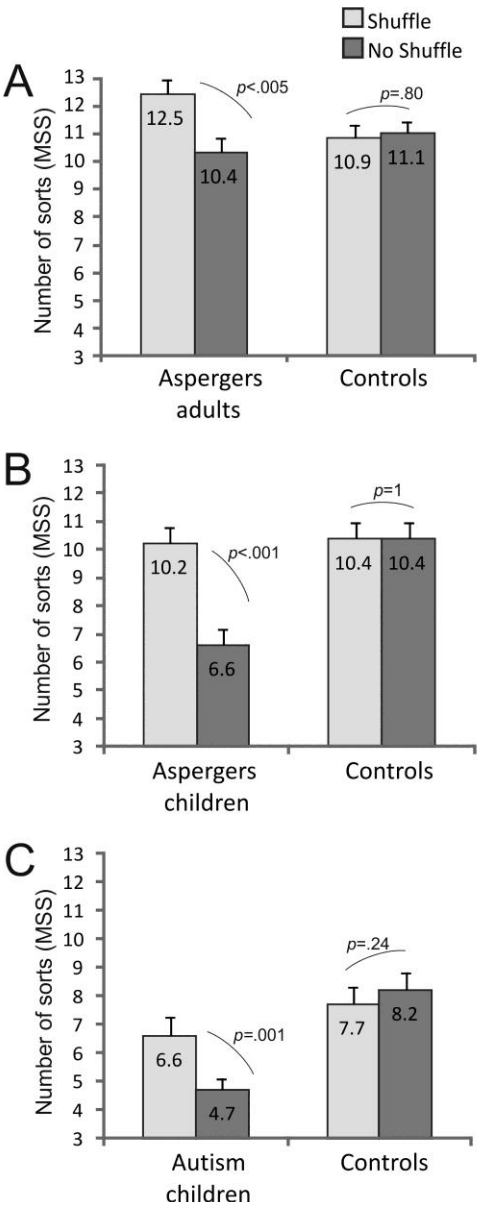

Figure 6.3. The results for the three ASD groups and their controls are shown in the Shuffle Task and No Shuffle Task. The y-axis shows the mean scaled score for correct number of card sorts made. Linear trend lines and standard errors are shown.

Discussion

The ability to (i) form new concepts from scratch (without having to visually disengaging attention, 'shuffle' condition) and to (ii) form new concepts whilst having to disengage attention from a previous concept, which remained physically present and attended ('no shuffle' condition), was investigated in children and adults diagnosed with ASD and typically-developed (TD) individuals. The results indicated that none of the three ASD groups was impaired in concept switching, provided that they did not have to disengage their attention from a previously identified card sort that remained physically present and attended. The results therefore indicate that individuals with ASD suffer from 'sticky attention' (cf. Wilson et al., 2006) but only when the concept that has to be abandoned does not physically remain present.

Deficits in attentional flexibility have been extensively documented in autism (e.g. Rhinehart et al., 2001). It is postulated that as social interaction involves complicated, unpredictable mental changes, such as when reading behaviour and mental states of others, that this reflects an impairment in the development of Theory of Mind (ToM) (Baron-Cohen, 1995). Other theories argue that there is a general underlying executive functioning deficit in autism, suggesting that individuals with ASD fail in tasks involving planning, working memory, impulse control, inhibition and, importantly, cognitive flexibility (Ozonoff & Jensen, 1999).

Most previous research does not discriminate between the executive functions of concept formation and concept switching (e.g. Delis et al, 2001). This study attempted to disentangle the two functions to investigate the nature of deficits in executive functioning in ASD further. A previous study by Landry and Bryson (2004) found that autistic subjects do not show a deficit in concept formation when they do not have to first disengage from a previous concept. In that study, the researchers measured the participant's eye gaze in two conditions; the first required an individual to shift their attention from one stimulus to another. This involved a stimulus presented on a computer screen, then after a short interval, replaced by another. The second condition involved stimuli presented simultaneously on a computer screen. In the second condition, autistic children showed a profound deficit in disengaging visual attention, while in the first condition they performed similarly to typical children and children with Down's Syndrome. This finding is reminiscent of findings in typically-developing 2-month old children, who show sticky visual attention, failing to disengage from a stimulus as flexibly as older children (Hood & Atkinson, 1993).

It is possible to argue that the inflexibility found in the no-shuffle condition was caused by hysteresis, which hampered the ability for the ASD groups to disengage their attention from one card sort to another. Hysteresis involves the persistence of percepts despite changes in extrinsic parameters to values favouring an alternative (Hock, Kelso & Schoner, 1993).

An example of this is the rabbit/duck illusion, where individuals with and without ASD typically tend to flip back and forth between percepts, showing the ability to ‘reverse’ and see both interpretations, when they are told there are two possible interpretations (Ropar, Mitchell & Ackroyd, 2003; Sobel, Capps & Gopnik, 2005). However, when participants are not told there are two possible interpretations, then children with ASD tend not to shift spontaneously to the alternative interpretation.

We found that the ASD groups performed similarly to controls when they visually disengaged from a correctly sorted card set in the shuffle condition. It cannot be excluded that, despite the visual/physical removal of the previously selected configuration in the shuffle condition, the participants did maintain a mental representation of that last configuration. Just because the examiner had shuffled the cards into a visually disorganised pattern, doesn’t mean to say that the subject had also shuffled its mental representation of the previous configuration. However, even if we assume that the ASD participants did maintain a mental representation of the previous configuration in the shuffle condition, we can conclude that they were not hampered by this mental representation when having to come up with a new sort. At least not more so than the controls, as ASD and control participants performed equally well in the ‘shuffle’ version of the task. However, the ASD participants were hampered by the persistence of the visual/physical representation of the previously selected configuration. This is reminiscent of the observation by Hughes and Russell (1993), who spoke about the difficulty children with autism experience to ‘disengage from the salience of physical reality’. Our results support this contention, as they emphasise the distinction between a mental representation and a physical representation of a particular stimulus configuration. For the autistic mind, the latter seems to have a salience that makes it hard to disengage.

Computerised versions of the WCST and manipulated procedural versions have shown that autistic individuals can achieve the same as typical individuals (Tsuchiya et al, 2005). It is proposed that deficits in the sorting task found in ASD groups are due to too many social demands imposed on the subject (Ozonoff, 1995). For this reason, in this task we did not compare the verbal description score made by subjects about the card sets, only the number of correctly identified card sorts.

Summary

In summary, the aim of the current study was to determine whether an established executive functioning task, the D-KEFS sorting task, which is typically used to measure cognitive flexibility, can be used in a unique way to study the influence of the 'salience of the physical reality', on concept formation and concept switching. The current results show that there was no significant difference between individuals with ASD and typical individuals when the 'salience of the physical reality' was removed (shuffle condition). However, the ASD groups performed significantly poorer than the controls when the 'salience of the physical reality' was present (no-shuffle condition). The findings thus support an 'attentional flexibility' deficit in autism, but only when disengagement from physical reality is required.

CHAPTER 7: The D-KEFS Card Sorting and Twenty Questions Tasks

The Delis-Kaplan Executive Functioning System (D-KEFS; Delis, Kaplan & Kramer, 2001) investigates cognitive abilities such as attention, perception and language and higher-level cognitive abilities, such as concept formation, inhibition, planning, and cognitive flexibility, indiscriminately. Another classic executive function attributed primarily to the frontal lobes is the ability to inhibit responding to the immediate physical environment, in order to allow an individual to engage in abstract, creative thought. Patients with frontal lobe damage often have difficulty in disengaging their attention from the immediate environment in order to perform higher level tasks. The D-KEFS Twenty Questions Task and the Trail Making Task were selected because they are designed to assess executive functions such as concept formation and concept switching.

Two tasks from the D-KEFS were selected that claim to measure concept forming (Twenty Questions Task) and concept switching (Trail Making Task). The aim of this was to investigate how the children and adults with Asperger's Syndrome (AS) perform incomparison to typically developed (TD) individuals on already established tasks, measuring cognitive flexibility.

Method

Participants

The participants described in these studies are a subset of those from the Silhouette (Re-)Conceptualisation study.

Clinical groups

The clinical groups consisted of eleven children (10 males, 1 females mean age = 13.2 years, SD = 1.0) recruited through schools in Hull, and twenty-two adults (16 males, 6 females mean age = 19.5 years, SD = 7.8), recruited through universities in the North-East of England (UK). All these participants had previously received a diagnosis of AS or High Functioning Autism (HFA), based on DSM-IV criteria (American Psychiatric Association: APA, 2000). These diagnostic evaluations involved a review of prior psychology ASD assessments and completion of the ADOS (Autism Diagnostic Observation Schedule, module 3 or 4: Lord et al., 1999) with the examiner. Adult participants completed the Autism Quotient :AQ (Baron-Cohen, 2001) and parents of children completed the Adolescent Ad-AQ 11-15 years (Baron-Cohen, Knickmeyer & Wheelwright, 2006) about their child, which were used as an additional screening tool and as exclusion criteria. Overall, the mean child and adult ADOS score was 8.1 (SD = 0.9) and the mean AQ score was 32.3 (SD = 7.8) *(see Table 7.1),* All adults and children met the criteria for AS, as there was no history of language delay and no cognitive impairments

All the children and adults in this study had an IQ within the average range when assessed using the Wechsler Adult Intelligence Scale (WAIS III; Wechsler, 1997) or Cognitive Ability Tests Three (CAT-3, Lohman, Hagen & Thorndike, 1995); see Table 7.1 for participant characteristics. They did not have any language difficulties and did not vary significantly in verbal or non-verbal ability. Overall the mean child and adult cognitive ability score was 109.8 (SD = 15.7), assessed using the WAIS-III and CAT-3.

Control groups

Twenty-one TD adults (8 males, 13 females mean age = 20.9 years, SD = 3.5), that did not differ significantly from the AS-adult group in terms of chronological age and cognitive ability, and 16 TD children (11 males, 5 females mean age = 13.5 years, SD = 1.5), that did not differ significantly in chronological age and overall (verbal and non-verbal) cognitive ability (using the same appropriate cognitive measures as the clinical group). The adult controls were all Hull university students and the children were at typical schools in Hull. Adult participants completed the AQ, and parents of children were asked to complete the

AdAQ 11-15 years about their child, as a screening tool for autistic traits and as a possible exclusion criterion.

The cognitive ability for children was assessed using the CAT-3 and adults completed a WAIS-III. Overall, the mean child and adult IQ score was 109.5 (SD = 8.5) and the mean AQ score was 12.4 (SD = 4.2) *(see Table 7.1).*

GROUP	n	Age	Sex	AQ	T	V	P	ADOS
Asperger's	33 (22 A, 11 C)	19.5 (7.8)	26 M, 7 F	32.3 (7.8)	109.8 (15.7)	110.8 (17.3)	107.2 (15.7)	8.1 (0.9)
Control	37 (21 A, 16 C)	17.7 (4.6)	19 M, 18 F	12.4 (4.2)	109.5 (8.5)	110.4 (12.1)	108.8 (13.0)	

Table 7.1.Participant characteristics. Age is in years. (F) female, (M) male. (AQ) Autism-spectrum Quotient. CAT-3 and WAIS-III-T total scores, (V) verbal scores,(P) non-verbal-performance scores. Standard errors are shown between brackets.

Procedure

Prior to the experiment, all adult participants completed the AQ, and parents of all children completed the child 11-15 years version of the AQ (Ad-AQ) both questionnaires take around 5 minutes to complete. All adults and children in the AS group completed Module 3 or 4 of the ADOS (depending on the individual's chronological age and cognitive ability) with the examiner (HB), which takes around between 40-60 minutes to complete (depending on the participant's responses). All Adult participants completed the WAIS-III (with examiner HB) and children completed the CAT-3 (with their class teacher), each taking around 90 minutes. Participants were seated opposite the examiner. All instructions were presented visually via the stimulus book and were given verbally, throughout the experiment.

Two Tasks were selected from the Delis-Kaplan Executive Functioning System (D-KEFS): the Trail Making Task and the Twenty Questions Task.

The Trail Making Task

The Trail Making Task contains five different measures. The primary executive functioning measure is the number-letter switching condition, a visual-motor sequencing procedure *(see Figure 7.1),* which is a measure for flexibility of thinking. The other four measures of the D-KEFS test allow the examiner to quantify and derive normative data for several key component processes needed to perform the switching task. These fundamental components include visual scanning, number sequencing, letter sequencing and motor speed in drawing lines.

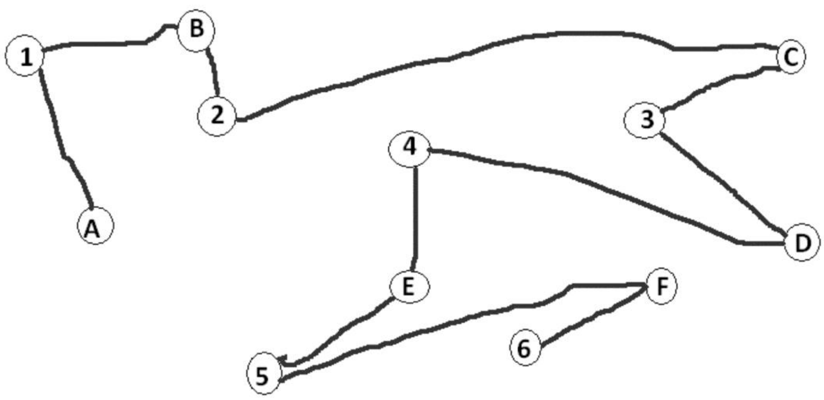

Figure 7.1.The participant is asked to join the letters and numbers together in alternating order, starting with the letter A, followed by the number 1, followed by the letter B, then the number 2 and so on.

These four conditions of the test take around 30-60 seconds in total to administer and act as a practice trial for the switching condition. They allow the examiner to quantify and derive normative data for several key component processes needed to perform the switching task. The participant is asked to draw lines via an A3 response sheet, marking all the letter ‘3’s in the visual scanning, joining up all the letters or numbers on the ‘letter’ or ‘number’ sequencing tasks, and join up all the circles, following a dotted line, on the motor speed task. The important task is the letter-number switching task, which involves the participant joining up all the letters and numbers in a sequence of letter, then number, A-1-B-2-C-3-D-4 and so on, until all numbers and letters are used.

The examiner recorded the time that the participant took to complete the sequence correctly and converted this into an achievement score, based on the age of the participant. All scores were standardised; higher scores indicate better performance.

Results

Adults: AS vs TD

The AS and TD groups did not differ significantly on the Letter-number switching task (AS: M = 10.9, SD = 2.8; TD: M = 11.5 , SD = 1.7; $t(39) = .79$, $p = .43$). Of the other four measures, the groups only differed on Visual scanning ($t(39) = 3.03$, $p = .004$), with the TD group scoring higher (M = 12.5, SD = 1.7) than the AS group (M = 10.7, SD = 2.1). On the remaining three measures (number sequencing, letter sequencing and motor speed) the groups did not differ (all *p*'s > .23, independent sample t tests, two-tailed).

Children: AS vs TD

The AS and TD children groups, like the TD and AS adults groups, did not differ on the Letter-number switching task (AS: M = 9.0, SD = 3.2; TD: M = 11.1, SD = 2.7; $t(24) = 1.8$, $p = .08$), although the difference approached significance. The AS and TD children groups also did not differ on any of the four remaining measures (all *p*'s > .084).

The Twenty Questions Task

In the Twenty Question Task, the participant is presented with a stimulus page, depicting pictures of 30 common objects *(see Figure 7.2)*, where their goal is to ask the fewest number of yes/no questions in order to identify the unknown target object. The 30 common objects can be grouped into various categories and subcategories that include varying numbers of objects. For example, the category *living things* has 15 objects, *animals* has 8 objects, and *birds* has 3 objects *(see Figure 7.3).*

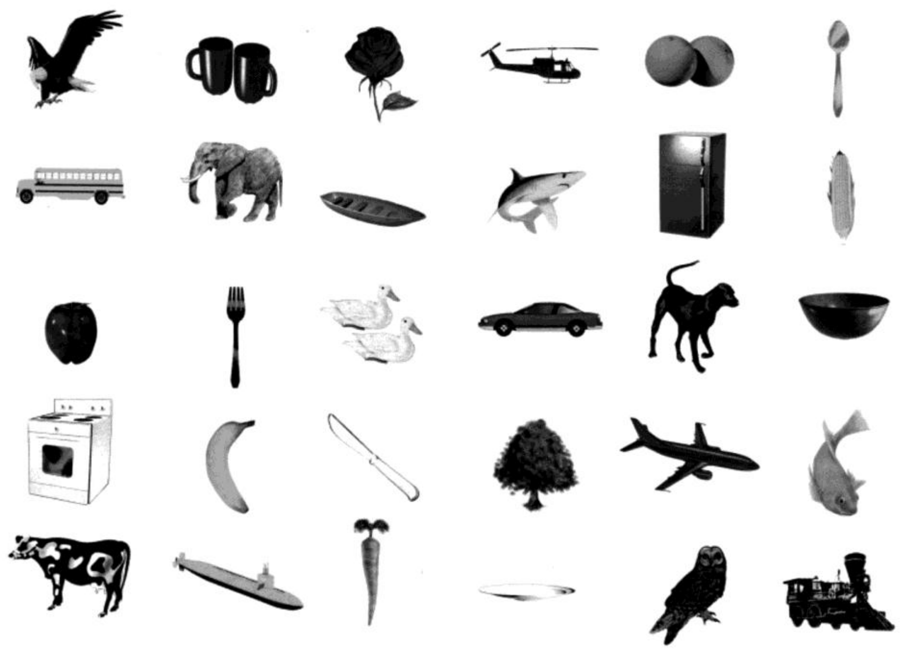

Figure 7.2. The 30 pictures shown to the examinee in the D-KEFS Twenty Questions Task.

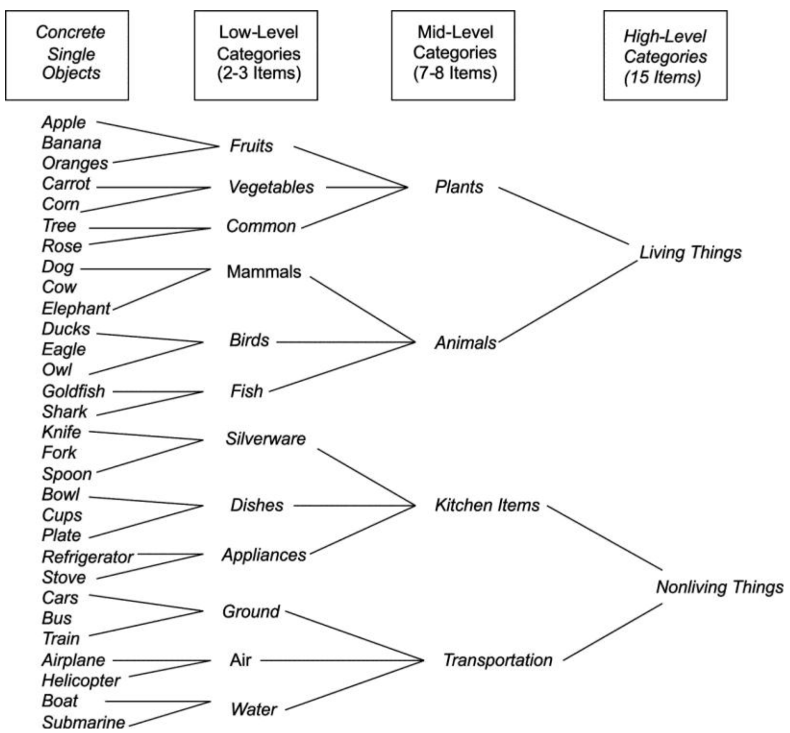

Figure 7.3. The 30 items listed (left) that the participant can see visibly on the D-KEFS stimulus book. There are 3 levels of categories (low, mid and high) that the participant may use in order to work out the object that the examiner has chosen.

The most effective problem solving strategy in this task is for the examinee to ask the yes/no questions that eliminate the maximum number of objects whether the examiners response is yes or no. For example if the examinee asks “Is it a living thing?” half of the objects (15/30) are eliminated regardless of the examiners answer. Thus the initial question should reflect a high level of abstract thinking (in contrast, the question “Is it a train?” will only eliminate one object).

The examiner recorded all questions, the number of potential objects eliminated by the first question (initial abstraction) and the total number of questions asked. The total number of questions asked was then standardised for the participant’s age (achievement score).

Results

Adults: AS vs TD

The AS and TD groups did not differ significantly on the Achievement measure (AS: M = 12.3, SD = 2.2; TD: M = 12.5, SD = 2.2; $t(39) = .32$, $p = .75$). The groups did differ significantly on Initial Abstraction ($t(39) = 3.0$, $p = .005$), with the AS group (M = 13.9, SD = 3.0) scoring higher than the TD group (M = 11.3, SD = 2.4), but did not differ on Total Questions ($t(39) = .14$, $p = .89$) *(see Figure 7.4).*

Children: AS vs TD

In contrast to the adults, the children AS and TD groups did differ significantly on the Achievement measure ($t(24) = .26$, $p = .014$). The TD children (M = 12.6, SD = 2.0) performed better than the AS children (M = 10.3, SD = 2.7). The groups also differed significantly on Total Questions ($t(39) = .14$, $p = .89$), with again the TD group (M = 12.1, SD = 1.5) performing better than the AS group (M = 10.3, SD = 3.0). On the Initial Abstraction they did not differ ($t(24) = .96$, $p = .35$) *(see Figure 7.4).*

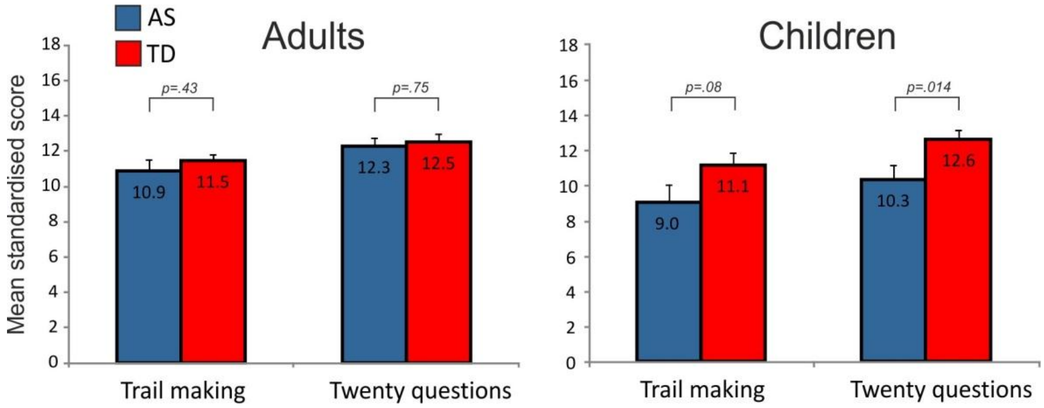

Figure 7.4. The results of the TD and AS groups, separated in adults and children, on two tasks of the D-KEFS. For the trail making task, scores on the Letter-Number Switching task are shown. For the Twenty questions task, the Achievement scores are shown.

Discussion

The results of the Twenty Questions Task showed no significant group difference for initial abstraction, total number of questions asked or overall achievement. The results do not support previous findings (Minshew et al., 1994) or a deficit for concept formation. Minshew, Meyer & Goldstein (2002) found that children and adults with autism were significantly less likely to ask questions that eliminated categories of at least two items at a time, and tended to rely on serial guessing (or *hypothesis-testing* questions) as their main strategy (e.g. "Is it the train?).

The results of the Trail Making Task showed a significant group difference in visual scanning, number sequencing and letter-number switching, with AS participants being poorer in all three conditions. However, no significant effect was found for letter sequencing and motor speed. Previously, a profound deficit was found with adults and adolescents with

Autism and AS in every condition of the Trail Making Task and more profoundly in the switching condition (Minshew et al., 2002; Kleinhans, Akshoomoof & Delis, 2005).

It is concluded from the additional studies, that individuals with AS may not have a deficiency in the forming of verbal concepts as an essential strategy to solve problems. They do however, show a profound deficit in switching concepts and this may be related to sequencing and visual scanning. A limitation of the study was that a small sample size was used, making it difficult to generalize the findings to the wider population. Also, the D-KEFS is that the tasks do not isolate executive functions 'concept formation' and 'concept switching', it is therefore difficult to investigate where exactly the deficit in ASD lies.

The a-typical findings in the additional studies could also be explained by the autism severity in the clinical sample. Only individuals with a mild form of autism (AS) took part in the additional studies due to time restraints, children with autism and learning difficulties were not examined. The Trail Making Task also incorporates static, inanimate stimuli and the Twenty Questions Task does not actively involve switching concepts.

The novel experiments described in this thesis aim to investigate concept formation and switching as separate functions and look for category-specific deficits, such as animate vs. inanimate differences in individuals with varying degrees of autism and typical individuals with varying degrees of autistic traits.

CHAPTER 8: The Ratio Tasks

The Ratio Tasks were conducted to investigate whether the removal of the requirement to gain access to animate or inanimate object categories might remove deficits that individuals with AS might have. If so, then that would leave open the possibility that the AS deficit in the Silhouette Reconceptualisation Task might have been due to difficulties in accessing the categories stored in memory. Further, the requirement to switch concepts has been removed in the Ratio Tasks. Two different versions were tested: the Picture and the Word Ratio Tasks (*see Figure 8.1)*.

Method

The participants used in these studies were a subset of those from the Silhouette (Re-)Conceptualisation study.

The Ratio Picture Task

Participants

Clinical group:

The clinical group consisted of eleven adults (8 males, 3 females; Mean age = 22.8 years, SD = 7.9), recruited through disability services at Universities in the North-East of England (UK). All these participants had previously received a diagnosis of high-functioning autism or Asperger's Syndrome (AS), based on DSM-IV criteria (American Psychiatric Association, APA 2000). Prior to participation, evidence of previous diagnostic evaluations were acquired and participants were required to complete the ADOS (Autism Diagnostic Observation Schedule, module 3 or 4: Lord et al., 1999, examiner: HB). Based on these assessments, all participants met the criteria for AS, they did not have any language, learning difficulties and did not vary significantly in verbal or non-verbal ability. Participants completed the AQ (Baron-Cohen, 2001), which was used as an additional screening tool and as an exclusion criterion. Overall, the mean ADOS score was 8.5 (SD = 0.8) and the mean AQ score was 30.1 (SD = 7.7) *(see Table 8.1).* All the participants in this study had an IQ within the average range when assessed using the Wechsler Adult Intelligence Scale (WAIS III; Wechsler, 1997) *see Table 8.1* for participant characteristics.

Control group:

Seven typically developed (TD) adults (2 males, 5 females; mean age = 20.1 years, SD = 1.8), were recruited from the university of Hull. The participants either took part for a fee or for research credits. Participants completed the AQ as a screening tool for autistic traits and as a possible exclusion criterion (Mean = 16.1, SD = 5.2). One of the participants completed the WAIS-III with the examiner (Full Scale IQ = 110) *(see Table 8.1).*

TASK						WAIS-III			
		n	Age	Sex	AQ	IQ-T	IQ-V	IQ-P	ADOS
RATIO PICTURE	AS	11	22.8 (7.9)	8 M, 3 F	35.7 (5.3)	113 (9.3)	112 (10.5)	113 (14.4)	8.5 (0.8)
	Control	7	20.1 (1.8	2 M, 5 F	13.3 (4.4)	110	110	110	
RATIO WORD	AS	3	20.3 (1.2)	3 M, 0 F	25.0 (7.0)	111 (14.0)	117 (17.8)	101 (8.7)	8.7 (0.6)
	Control	11	20.6 (1.1)	4 M, 7 F	13.9 (5.1)	114 (2.9)	118 (4.0)	108 (2.1)	

Table 8.1.Participant characteristics. Age is in years. (F) female, (M) male. (AQ) Autism-spectrum Quotient. CAT-3 and WAIS-III-T total scores, (V) verbal scores,(P) non-verbal-performance scores. Standard deviations (SD) are shown between brackets.

Procedure

The participant was presented with an ambiguous (morphed) interpolation of two objects (objects A and B) on a computer screen (50% of objects was animate and 50% was inanimate). The interpolated object contained either 40%A-60%B, 45%A-55%B, 50%A-50%B, 55%A-45%B or 40%A-60%B. *(see Figure 8.1)*. The two objects (A and B) were presented below the interpolated object, at either end of a 5 point scale, and the participant is asked to indicate whether the object is more similar to object A or object B on the scale by pressing a key from 1 to 5 (1 = 'mostly similar' to Object A, 2 = 'slightly similar' to object A, 3 = equally similar to objects A and B, 4 = 'slightly similar' to object B, 5 = 'mostly similar' to Object B). Half of the trials the animate object was presented on the left (A) and the inanimate on the right (B), and on the other half this was reversed. A total of 124 trials were presented.

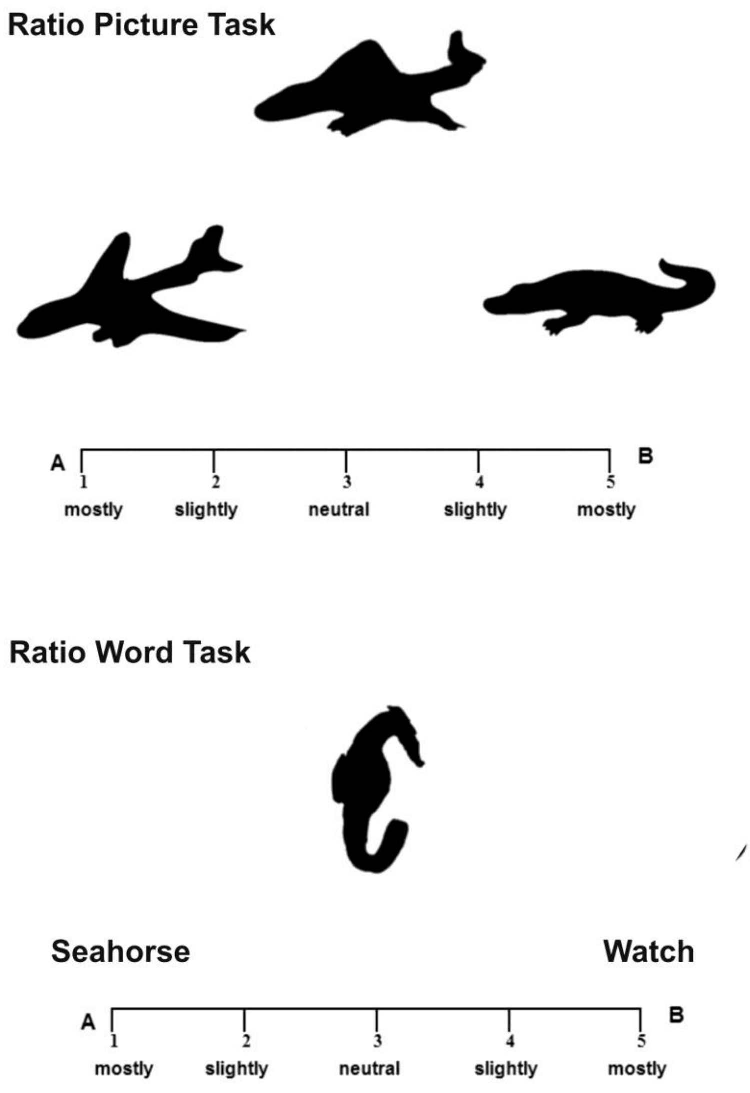

Figure 8.1. Illustration of the Ratio Picture (top panel) and Ratio Word (bottom panel) tasks. In both examples, the interpolated objects contained 50% of object A and 50% on object B.

Results

A 5x2 repeated measurers ANOVA with Condition (40%A-60%B vs. 45%A-55%B vs. 50%A-50%B vs. 55%A-45%B vs. 40%A-60%B) as within-subjects variable, and Group (AS vs. TD) as between-subjects variable, showed a significant main effect for Condition ($F(4, 64) = 126$, *p*< .001, η_p^2 = .89), but no significant effect for Group (*F*(1, 16) = .21, *p* = .66, η_p^2 = .013), nor for the Condition by Group interaction factor (*F* (4, 64) = .56, *p* = .70, η_p^2 = .034) (s*ee Figure 8.2).* The results of the Ratio Picture Task suggest that individuals with AS are just as likely as controls to indicate that an ambiguous objects looks more like an animate objects (or an inanimate object) as the TD group. Thus, when there is no requirement to switch between concepts and to access new concepts, the AS group does not differ from the control group.

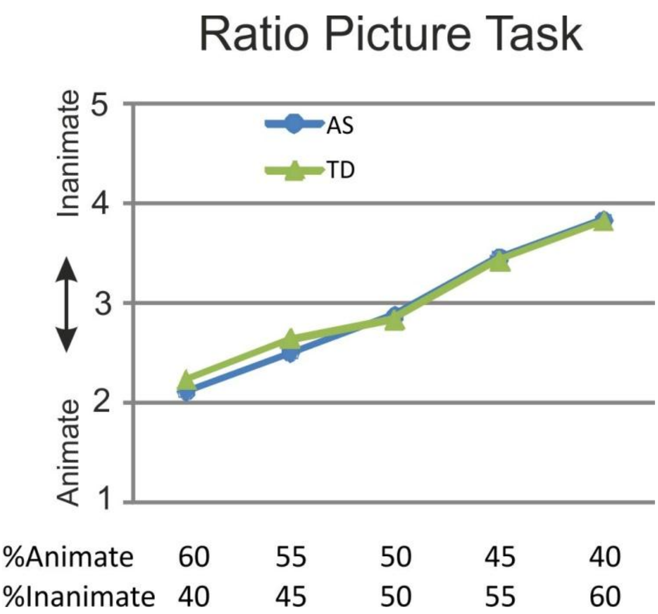

Figure 8.2. Results of the Ratio Picture Task. Vertical axis shows the responses on the 5-point scale. Horizontal axis shows the different percentages of animate and inanimate contained in the interpolated object.

The Ratio Word Task

In principle the Ratio-Picture Task could have been solved by comparing object shapes *per se*, without paying any attention to the category the objects belonged to. Therefore, the Ratio-Word Task was designed, in which the pictures of objects A and B were replaced by the names of objects A and B.

Participants

Clinical group:

The clinical group consisted of three adults (all male, mean age = 20.3 years, SD = 1.2), recruited through disability services at Universities in the North-East of England (UK). All these participants had previously received a diagnosis of high functioning autism (HFA) or AS, based on DSM-IV criteria (APA, 2000). Prior to participation, evidence of previous diagnostic evaluations were acquired and participants were required to complete the ADOS (Autism Diagnostic Observation Schedule, module 3 or 4: Lord, Rutter, DiLavore and Risi, 1999, examiner: HB). Based on these assessments, all participants met the criteria for AS as there was no history of language delay or cognitive impairment. Participants completed the AQ (Baron-Cohen, 2001), which was used as an additional screening tool and as an exclusion criterion. The mean ADOS score was 8.7 (SD = 0.6) and the mean AQ score was 25.0 (SD = 7.0) *(see Table 8.3).* All the participants in this study had an IQ within the average range when assessed using the Wechsler Adult Intelligence Scale (WAIS III; Wechsler, 1997), see Table 8.1 for participant characteristics.

Control group:

Eleven TD adults (4 males, 7 females; mean age = 20.6 years, SD = 1.1), were recruited from the University of Hull. The participants either took part for a fee or for research credits. Participants completed the AQ as a screening tool for autistic traits, and as a possible exclusion criterion (Mean = 13.9, SD = 5.1). Three of the participants completed the WAIS-III (HB) (Mean = 114, SD = 2.9) *(see Table 8.1).*

Procedure

The participant was presented with an ambiguous (morphed) interpolation of two objects (objects A and B) on a computer screen. Instead of the objects themselves, the names of objects A and B were shown (50% was animate and 50% was inanimate). As in the Ratio-Picture task, the interpolated object contained either 40%A-60%B, 45%A-55%B, 50%A-50%B, 55%A-45%B or 40%A-60%B (see Figure A5). The names of objects A and B were presented below the interpolated object, at either end of a 5 point scale. The participant was asked to indicate whether the object is more similar to object A or object B on the scale by pressing a key from 1 to 5 (1 = 'mostly similar' to Object A, 5 = 'mostly similar' to Object B). Half of the trials the animate object name was presented on the left (A) and the inanimate name on the right (B), and on the other half this was reversed. A total of 124 trials were presented.

Results

Similarly to the Ratio Pictures task, a 5x2 repeated measurers ANOVA with Condition (40%A-60%B vs. 45%A-55%B vs. 50%A-50%B vs. 55%A-45%B vs. 40%A-60%B) as within-subjects variable, and Group (AS vs. TD) as between-subjects variable, was performed. It showed a significant main effect for Condition ($F(4, 52) = 49$, $p< .001$, $\eta_p^2 = .80$), but no significant effect for Group ($F(1, 13) = 1.9$, $p = .19$, $\eta_p^2 = .13$), nor for the Condition by Group interaction factor ($F\ (4, 52) = 2.5$, $p = .055$, $\eta_p^2 = .16$), although it approached significance. The results of the Ratio Word Task suggest that also when there is no possibility to directly compare shapes, individuals with AS are just as likely as controls to indicate that an ambiguous objects looks more like an animate objects (or an inanimate object) as the TD group *(see Figure 8.3).*

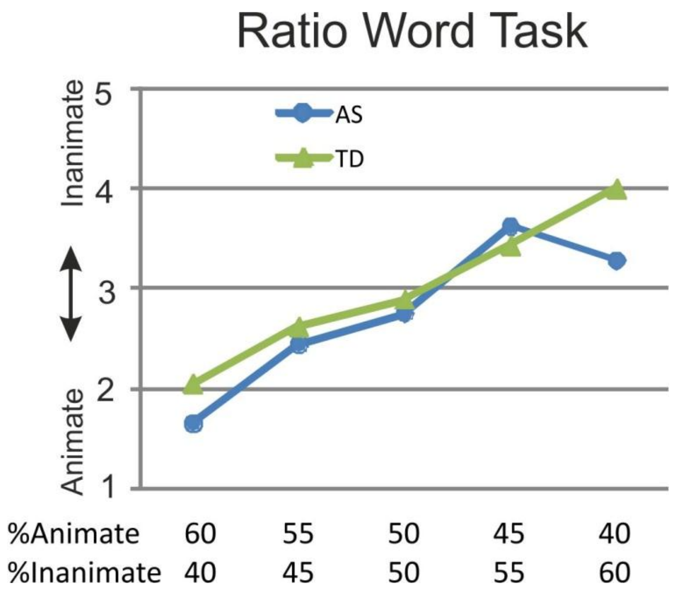

Figure 8.3. Results of the Ratio Word Task. Vertical axis shows the responses on the 5-point scale. Horizontal axis shows the different percentages of animate and inanimate contained in the interpolated object.

Discussion

Crucially, the Ratio Tasks did not require the participant to access object categories, nor did they require the participant to switch between concepts. The underlying idea was that if the AS individuals would show no deficit on the Ratio tasks, then it might well have been the case that they failed on the Re-conceptualisation and Gabor Tasks (Chapters 3, 4 and 5) because of the requirement to access new categories and/or the requirement to switch between concepts. On the other hand, if the AS participants would show deficiencies on the Ratio tasks then that would suggest that other deficiencies may be involved.

The Ratio Picture Task measured the participant’s ability to identify similarities between two (unmorphed) objects A an B and an ambiguous interpolation of objects A and B (Object C). It could be that TD individuals would be more likely to interpret the interpolated object as animate, as Verstijen and Wagemans (2004) found that typical individuals were biased towards the interpretation that an ambiguous figure was animate rather than inanimate. In contrast, individuals with ASD have been found to be less likely to interpret an object as animate, based on its motion (Rutherford, Pennington & Rogers, 2006).

However, a limitation to the Ratio Picture Task was that the shapes of the two objects (A and B) that the participant had been asked to compare to Object C, were presented below. This could mean that the participant was simply comparing the geometrical shapes of the objects and was not accessing animate or inanimate categories. The Ratio Word Task was designed to bypass this problem in this task, the name of Object A / B was presented instead of the silhouettes. In this way the participant would have to think about what the animate or inanimate object would look like. The results of both Ratio Tasks indicated that the individuals with AS were just as likely as TD controls to indicate that an ambiguous objects looked more like an animate objects (or an inanimate object) as the TD group. A limitation of the ratio tasks are that a small sample size was used, making it difficult to generalize the finding to the wider population. However, the findings suggest that the deficiency in the AS group on the Re-conceptualisation Tasks was indeed related to the ability to access object categories and/or the ability to switch between categories.

CHAPTER 9. DISCUSSION

The aim of this thesis was to explore individual limitations in the perceptual-cognitive abilities of forming concepts (conceptualisation) and of switching between concepts (reconceptualisation) in individuals with varying degrees of autism spectrum disorder (ASD) and in typically-developed (TD) individuals. Further aims were to examine whether the animate or inanimate nature of the concepts affected the (re-)conceptualisation abilities, and whether this effect varied along the autism spectrum. We also aimed to examine the impact of the 'salience of physical reality' on the (re-)conceptualisation abilities, and whether there is a continuum in concept forming and/or switching underlying the entire autism spectrum, extending into the TD population. The basic experimental paradigm involved recognition of ambiguous and impoverished objects. Distinct animate and/or inanimate objects were morphed into each other, resulting in a sequence of interpolations with decreasing proportions of one object and increasing proportions of the other object. Participants were required to identify the newly emerging object. There were two distinct versions: the Conceptualisation Task, in which participants had to form a new concept from 'scratch', and the Reconceptualisation Task, in which an existing concept had to be traded in for a new concept. The experiments were performed on three different clinical groups: adults with Asperger's syndrome (AS), children with AS, and children with autism. A control group consisted of individuals that did not differ in sex and cognitive ability. In addition, on the basis of their score on the Autism Quotient (AQ), approximately the top and bottom 20% of TD adults were allocated to either a low or high AQ group.

Four new experimental paradigms were employed: (Re-)conceptualisation Silhouette Task *(see Chapters 3 and 4)*, (Re-)conceptualisation Gabor Task *(see Chapter 5)*, D-KEFS Sorting Task with a unique added 'No Shuffle' condition, where the cards were not shuffled after each correct sort *(see Chapter 6)* and an Object-Ratio Task (*see Chapter 8*). In addition, the performance of the participant groups on these new tasks was compared with their performance on existing concept-switching tasks that are part of the Delis-Kaplan

Executive Functioning System (D-KEFS): the Trail making Task and the Twenty Questions Task (*see Chapter 7)*.

Results

In the Silhouette (Re-)Conceptualisation Task in Adults *(see Chapter 3),* the first aim was to determine whether the abilities for conceptualisation and reconceptualisation can be differentiated. The current results did not indicate that the tasks affected the groups differently; the overall response patterns obtained in the two tasks were quite similar (no significant Task by Group interaction). However, when the nature of the emerging object was taken into account the two tasks did differentiate between groups. This related to the second aim, which was to find out whether an impairment in reconceptualisation might be related to the category the objects belong to (animate vs. inanimate). We found that the Reconceptualisation Task brought out a specific deficit in the AS group in that they no longer showed an ‘animate advantage’. The third aim was to investigate if deficiencies in the ability to form concepts, and/or switch between them, form a continuum underlying the entire TD population. The current results provided convincing evidence supporting this idea, as the high AQ group showed a similar result pattern to the AS group, but to a lesser extent.

Similarly to Chapter 3, the Silhouette (Re-)Conceptualisation Task in Children *(see Chapter 4)*, the aim of this study was to determine whether the abilities for conceptualisation and reconceptualisation can be differentiated. However, in Chapter 4, children with varying degrees of Autism Spectrum Disorder (ASD), including AS and autism, were included, whereas in Chapter 3 the clinical group consisted exclusively of adults with AS. Overall, we found that the number of frames required to correctly identify the objects was significantly increased in both the AS and Autism group, compared to the high and low functioning control groups, respectively. However, the autism group did differ from the AS group in that they showed no impairment (compared to controls) for inamimate objects on either task, whereas the AS group was impaired for inanimate objects on both tasks. Remarkably, the animate advantage that the children with autism showed in the Conceptualisation Task reversed in the Reconceptualisation Task: they became better in identifying the inanimate objects as compared to animate objects.

The findings of the Chapters 3 and 4 (Burnett & Jellema, 2012; *see Figure 9.1*) support a processing deficit in autism. It is possible, however, that attentional dysfunction does not manifests as a general deficit in autism, as children with autism were not impaired in recognising inanimate objects. Instead it could be postulated that the underlying deficit is, more specifically, an impairment in attention to complex and unpredictable animate stimuli.

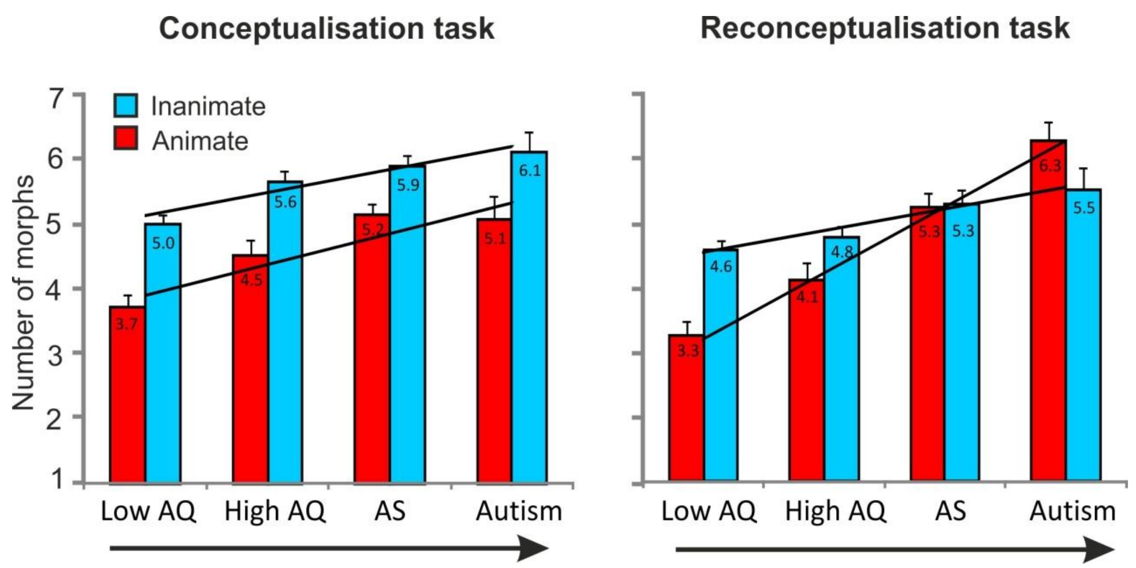

Figure 9.1.Summary of the results of Chapters 2 and 3 on the Conceptualisation and Reconceptualisation Tasks for the four participant groups occupying different positions in the ASD spectrum (most severe on the right). Linear trend lines are only shown for illustrative purposes as the groups are on an ordinal scale.

The Gabor Task *(see Chapter 5),* similar to the (Re-)Conceptualisation Tasks aim was to determine whether the abilities of conceptualisation and reconceptualisation can be differentiated in AS. However, two important changes were made. Impoverished objects were used, giving the illusion that the objects emerged out of a ‘fog’ or ‘mist’. This gave the participant less (local) detail or clues about the to-be-identified end-object. In addition, the start-object in the switching condition (Reconceptualisation Gabor Task) remained present and did not diminish throughout the identification procedure. The idea was that this might make disengagement from the distractor object more difficult due to the ‘salience of physical reality’. Both groups found the Reconceptualisation Gabor Task significantly more difficult than the Conceptualisation Gabor Task. However, on the Reconceptualisation Gabor Task, the AS group performed considerably poorer when the endobject was animate, compared to the TD group. This animacy deficiency was most likely ‘brought out’ by continued physical presence of the distractor object, which supports the ‘salience of physical reality’ hypothesis.

The aim of the Card Sorting Task *(see Chapter 6)* was to determine whether an established executive functioning task, the D-KEFS Sorting Task, which is typically used to measure cognitive flexibility, can be used in a unique way to study the influence of the ‘salience of the physical reality’ (forming a new concept in the continued physical presence of another concept(s), on concept formation and concept switching. The current results show that there was no significant difference between individuals with ASD and TD individuals when the ‘salience of the physical reality’ was removed (shuffle condition). However, the ASD groups performed significantly poorer than the controls when the ‘salience of the physical reality’ was present (no-shuffle condition). The findings thus support an ‘attentional flexibility’ deficit in autism, but only when disengagement from physical reality is required.

We started off by asking seven research questions (*see Chapter 1*). We will now try and answer them on the basis of the results of the experiments.

1 *Does it make a difference whether the forming of a new concept involves trading in an existing concept for a new one, or whether the new concept is formed from ‘scratch’? In other words, are forming and switching two distinct and different abilities? Are they differently affected in ASD?*

As most tasks involve presenting multiple stimuli simultaneously, it is often difficult to disassociate concept formation and concept switching. We aimed to investigate whether it made a difference if individuals with ASD have to visually disengage from one concept before identifying a new one.

We found evidence that the capacities for forming and switching concepts can be differentiated, but with two important, and revealing, restrictions. *(1)* The animate versus inanimate nature of the to-be-identified object has to be taken into account. *(2)* The physical versus mental presence of the distractor object has to be taken into account. Both restrictions are quit insightful regarding the nature of the switching deficiency in ASD.

With respect to the animate vs inanimate nature of the new concept, we found that reconceptualisation, but **not** the conceptualisation, hampered the recognition of animate objects, and that the extent of this deficit was related to the extent to which the individual possessed autistic(-like) traits. The more autistic(-like) traits, the larger the deficit in recognising animate objects. With respect to inanimate objects, there was also a trend towards more impairment at higher levels of ASD, but significantly weaker than the impairment for animate objects. The impairment for inanimate objects was not affected by the task. Thus, the recognition of inanimate objects was equally affected by the Conceptualisation and Reconceptualisation Tasks along the ASD spectrum.

The influence of the physical versus mental presence of the distractor object on the ability to reconceptualise will be discussed in the answer to Question 3.

The findings of the (Re-)Conceptualisation studies *(see Chapters 3, 4 and 5)* support the idea of an processing deficit in autism. It is possible, however, that attentional dysfunction does not manifests as a general deficit in autism, but specifically applies to animate objects/concepts. Thus, it could be postulated that the underlying deficit in ASD is an impairment in attending to complex and unpredictable animate stimuli, which is consistent with the findings in the current experiments. The idea has been discussed by Dawson and Lewy (1989), who propose that children with autism do possess a general impairment in orienting and switching attention, but these impairments are more evident for animate than inanimate stimuli. Similarly, Peirce, Gland and Schreibman (1997) found that children with autism were much poorer at identifying social cues when relating to stories containing multiple cues.

2 Is the forming of a new concept affected by the animate or inanimate nature of the concept?

We investigated whether forming or switching concepts was affected by the nature of the to-be-identified object. That is, if the end-object was animate or inanimate would individuals with ASD be poorer at either conceptualising or reconceptualising than TD individuals. The findings of the (Re-)Conceptualisation study *(see Chapters 3 and 4)* and the Gabor Tasks *(see Chapter 5)* support a processing deficit for animate objects in ASD. Adults and children with ASD were impaired at forming animate concepts as compared to TD individuals, and this deficit was increased when first having to disengage from a previously identified concept. Several neurological (Downing et al., 2004), behavioural (Hobson, 1987; Frith & Frith, 1999) and anecdotal (Kanner & Lesser, 1958) studies support the idea that individuals with ASD are impaired in the forming of animate concepts, but are relatively unimpaired in forming inanimate concepts (cf. Boucher & Lewis, 1992). A specific deficit in forming animate concepts would support previous findings of animate and social processing deficits in ASD (Brothers, 1990; Dunbar, 1998; Adolphs, 1999).

We examined the possibility that animate objects were easier to identify due to characteristics in their shape. However, this was excluded as a possibility as the animate and inanimate objects did not differ in compactness or homogeneity, suggesting that the objects were equally complex *(see Chapters 3, 4 and 5)*. We also examined the possibility that individuals with autism were less likely to generate animate guesses. Again this was excluded as a possibility as individuals with ASD were just as likely to generate animate guesses as the TD group *(see Chapters 3, 4 and 5)*. In fact, children with autism made significantly more animate guesses than control children. We also discussed the possibility that individuals with ASD have a deficit in establishing general abstract categories, which might selectively disadvantage the recognition of animate objects *(see Chapters 3, 4 and 5).* However, the animate subclasses that were used (e.g. butterfly, chicken, penguin) do not come in large varieties. Objects were chosen that were ‘typical’ and ‘familiar’ in nature, and most had standardised identification rates established (DeWinter & Wagemans, 2004).

3 Does it make a difference whether the distractor object (i.e. the object one has to disengage from) remains physically present during the time the new object has to be identified?

The physical reality can be quite salient for individuals with autism, possibly so much so that they cannot ‘escape’ from it. We specifically investigated the impact of the physical reality, referred to as the ‘salience of physical reality’ (Hughes & Russell, 1993), on the ability to disengage and form a new concept in two tasks, the Gabor Reconceptualisation Task *(see Chapter 5)* and the Card Sorting Task *(see Chapter 6)*. We investigated whether physical presence of the start-object hampered the identification of a to-be identified, new concept. In the Reconceptualisation Gabor Task *(see Chapter 5)*, the start-object remained physically present throughout the procedure whilst the to-be-identified end-object gradually emerged. Both the TD and AS participants were found to be significantly disadvantaged in this condition. However, the AS group were significantly more disadvantaged when the end-object was animate. In the Card Sorting Task *(see Chapter 6)*, participants were given a novel condition, where the cards were not shuffled by the examiner after each correctly identified sort, to see whether this would affect their ability to disengage from the first object. The ASD group were significantly disadvantaged in the No-Shuffle condition, but performed similarly to the controls in the Shuffle condition. The results of these two studies suggest that individuals with AS do have a switching deficit, particularly when the objects from which they have to switch away remained physically present.

4 Do individuals that occupy different positions on the autism spectrum (low Autism Quotient, high Autism Quotient, Asperger's syndrome, autism) differ in their ability to form new concepts?

We investigated whether there is an underlying continuum in concept forming/ switching in ASD, and whether this might extend into the TD population. The latter was investigated by subdividing the TD population in groups with low and high scores on the Autism spectrum Quotient (AQ, Baron-Cohen, 2002), which measures the extent to which TD individuals possess autistic-like traits. It has been suggested that in the TD population large differences already exist in the ability to switch between concepts (Verstijnen & Wagemans, 2004). In the Reconceptualisation Silhouette Task *(see Chapter 3)* the 'animate advantage' was significantly reduced in the AS group with respect to the low AQ group, while the high-AQ group occupied an intermediate position. This suggests that each individual occupies a position on an underlying continuum in concept switching, ranging from very poor to very adept, with individuals with ASD at the extreme poor end of the continuum and TD individuals with low AQ scores at the extreme low end. Again, it is possible that object recognition dysfunction does not manifests as a general deficit in autism, as there was a much smaller impairment in forming or switching concepts when the to-be-identified object was inanimate. It could be postulated that in real life there is an underlying continuum which is more specific to impairments in attention to complex and unpredictable social stimuli, and that the results on the current experiments with respect to animate objects are reminiscent of that.

Remarkably, in the Reconceptualisation Silhouette Task *(see Chapter 4)*, children with autism showed an advantage for identifying inanimate objects in the switching condition, in sharp contrast to all control and AS groups who showed exclusively animate advantages. Importantly, this suggests that the concept switching continuum also varies within the clinical autism spectrum population in relation to animate objects that is.

5 *If differences are found between the recognition of animate and inanimate objects (or concepts), was it then due to enhanced or impaired access to the animate or inanimate categories?*

It was important to examine whether the deficiency in recognizing animate objects/concepts found in the ASD groups was related to a problem in getting access to the categories of animate objects stored in memory. We examined this in two ways. First by comparing the number of animate and inanimate guesses made by the ASD and control groups in Chapters 3, 4 and 5. All incorrect guesses made by all participants on both tasks were recorded to be able to determine whether any differences existed between the participant groups in absolute number of guesses made, and/or differences in the relative numbers of animate and inanimate guesses. Overall, the AS and control groups made a similar percentage of animate and inanimate guesses. In the Reconceptualisation Task, children with autism, who performed the poorest of all groups and showed an advantage for identifying inanimate objects, surprisingly made significantly more animate guesses than the control group.

The second way to examine whether the problem was concentrated in the ability to access categories was the Ratio Task *(see Chapter 8).* The Ratio Task was specifically designed to investigate possible deficits in accessing animate or inanimate categories. An ambiguous interpolation of two objects A and B morphed together was presented to the participant, with the two original objects A and B presented below in either a picture or word format. The participant was given a 5 point scale to indicate whether the interpolated object was more similar to Object A or B. On this task no significant difference was found between the AS and TD group. Thus, when two endobjects (A and B) are provided right from the start, and the participant thus does not need to gain access to a particular category of object from memory, then the AS group performed as well as the TD group.

Although, the experiment involved a relatively small sample size, it leaves open the possibility that the deficiency of the ASD group on the Silhouette reconceptualisation task may have been due a compromised ability to obtain access to the object categories, but the guesses analysis basically already excluded this possibility. However, apart from the absence of a requirement to gain access to object categories, the Ratio tasks also did not require the participant to switch concepts. Therefore, the results of the guesses analysis and of the Ratio Tasks suggest that the deficit ASD individuals have in recognising animate objects is not related to gaining access to the animate concepts, but is related to the requirement to switch concepts.

6. Do the ASD groups differ from typical individuals in their local versus global processing style? Are they significantly more impaired when having to identify an object for which only global information is available?

Another aim was to investigate whether the presumed deficit in individuals with ASD in the global processing of objects (Frith, 1999) affects their ability to conceptualise and/or to reconceptualise. We restricted the amount of local information available about the to-be-identified end-object by creating the illusion that the objects came from a ‘fog-like mist’ *(see Chapter 5)*. This made the task more difficult and gave the participant less (local) detail or clues about the end-object. We investigated whether this restriction increased the animacy deficiency effect found in the Silhouette study *(see Chapters 3 and 4).*Both the TD and AS groups found the Reconceptualisation Gabor Task significantly more difficult than the Conceptualisation Gabor Task, for both animate and inanimate objects.

However, on the Reconceptualisation Gabor Task, the AS group performed a lot worse than the control group with respect to animate objects, whereas they performed as well as the controls with respect to inanimate objects. Thus, it seems that in the Reconceptualisaton Task, the removal of detail in the objects had an effect on the AS group on top of the effect one would expect due to the reconceptualisation requirement, but it only happened for animate objects, not for inanimate objects.

7 How does the clinical population in this study perform on already established concept formation and switching tasks?

We also aimed to investigate how individuals with AS perform on concept switching and cognitive flexibility tasks that have already been established in the literature and are routinely used as measures of executive functioning, such as the Delis Kaplan Executive Functioning System (D-KEFS). Three relevant sub-tests of the D-KEFS were used: The Twenty Questions Task and the Trail Making Task *(see Chapter 7)* and the Card Sorting Task (with shuffling, *see Chapter 6).* The results on these tasks were compared with the results on our own, newly designed, tasks. The results of the Twenty Questions Task do not suggest an impairment in concept formation in the AS population as no significant difference was found on the achievement score and total number of questions asked, between the AS and control groups. This is in contrast to previous findings with children with autism (e.g. Minshew et al., 1994).

Similarly, no significant differences between the AS and control groups were found on the Card Sorting Task with the implemented Shuffle Condition, nor on the Trail Making Task. A possible reason for the discrepancies with previous studies is that in the current study the AS group was very similar to the control group, in terms of intellectual abilities, daily routines and experiences (both groups consisted of students from Universities in the North-East of England). They basically only differed in one aspect: AS. Previous studies may have used less similar control group, while individuals with more severe forms of ASD may have been included.

Furthermore, these D-KEFS tasks alone do not provide much insight to the problem as they do not isolate the executive functions of concept forming and concept switching. The novel experiments described in Chapters 3-6, provide more detail as to where the deficit in concept forming lies. We know from the (Re-)Conceptualision and Gabor Studies that there is a deficit in forming concepts, especially when first having to disengage from a previously acquired concept and when the nature of the to-be-identified object is animate. We have also learned from the Card Sorting Task and the (Re-)Conceptualisation Gabor Task, that individuals with autism find concept forming even more difficult when there is the persistent presence of a previously identified concept, supporting the idea that individuals with autism suffer from the 'salience of physical reality'.

Conclusions and future research

Overall, the studies suggest that individuals with ASD are impaired in forming new concepts, especially when they first have to disengage their attention from a previously identified concept, which remains physically present, and when the concept is animate. This deficit also extends to the TD population (to those TD individuals with high AQ scores). The findings therefore support the notion of a concept forming and concept switching continuum, that is present not only in ASD, but also in the general population. The findings further suggest that individuals with ASD possess a processing deficit specifically for animate concepts/objects, which becomes worse with increasing ASD severity.

The results reported in this thesis provide interesting future research questions. As noted previously, individuals with ASD vary considerably in terms of autistic traits, intellectual ability and verbal skills. The studies that were employed involved mainly high-functioning autism and AS. The studies should therefore be extended to more severe forms of ASD. Also, the nature of the animacy deficit should be further investigated and the mechanism by which the physical reality exerts its influence of cognitive processing in ASD.

REFERENCES

Abelson, A. G. (1981). The Development of Gender Identity in the Autistic Child. *Child Care, Health and Development, 7*, 347-356.

Adolphs, R. (1999). Social Cognition and the Human Brain. *Trends in Cognitive Sciences, 3,* 469-479.

Adrien, J. L., Perrot, A., Sauvage, D., Leddet, I., Larmande, C., Hameurg, L., & Barthelemy, C. (1992). Early Symptoms in Autism from Family Home Movies: Evaluation and Comparison between 1st and 2nd Year of Life using I. B. S. E. Scale. *International Journal of Child & Adolescent Psychiatry, 55,* 71-75.

Allison, T., Puce, A., & McCarthy, G. (2000). Social Perception from Visual Cues: Role of the STS Region. *Trends in Cognitive Science, 4,* 267–278.

American Association on Mental Retardation (AAMR). (1992). Mental Retardation: Definition, Classification, and Systems of Supports. 9th Edition. Washington, DC: Author.

American Psychiatric Association. (2000). *Diagnostic and Statistical Manual of Mental Disorders*, American Psychiatric Publishing, Washington, DC, USA, 4th edition.

Asperger, H. (1944). Die Autistischen Psychopathen. ImKindesalter (Autistic Psychopaths in Childhood). *Archive fur Psychiatrie und Nervenkrankheiten, 117,* 76-136. (Reprinted in *Autism and Asperger's Syndrome*, by U. Frith, Ed., 1991, Cambridge, UK: Cambridge University Press).

Baddeley, A., & Wilson, B. (1988). Frontal Amnesia and the Dysexecutive Syndrome. *Brain and Cognition, 7*, 212-230.

Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the Autistic Child have a "Theory of Mind"?. *Cognition, 21*, 37-46.

Baron Cohen, S. (1987). Autism and Symbolic Play. *British Journal of Developmental Psychology, 5,* 139-148.

Baron-Cohen, S. (1989a). Are autistic children behaviourists? An Examination of Their Mental-Physical and Appearance-Reality Distinctions. *Journal of Autism and Developmental Disorders, 19,* 579-600.

Baron Cohen, S. (1989b). The Autistic Child's Theory of Mind: A Case of Specific Developmental Delay. *Journal of Child Psychology and Psychiatry, 30,* 285-298.

Baron Cohen, S. (1991). The Theory of Mind in Autism: How Specific is it? *British Journal of Developmental Psychology, 9,* 301-314.

Baron-Cohen, S. (1994). The Eye Direction Detector (EDD) and the Shared Attention Mechanism (SAM): Two Cases of Evolutionary Psychology in the Role of Joint Attention in Development, ed. C. Moore and P. Dunham. Erlbaum.

Baron-Cohen, S. (1995). *Mindblindness: An Essay on Autism and Theory of Mind.* MIT Press.

Baron-Cohen, S., Leslie, A., & Firth, U. (1995). Does the Autistic Child have a Theory of Mind? *Cognition, 21,* 37-46.

Baron-Cohen, S., & Swettenham, J. (1997).*Theory of Mind in Autism: Its Relationship to Executive Functioning and Central Coherence.* Handbook of Autism and Pervasive Developmental Disorders. New York: John Wiley and Sons, Inc.

Baron-Cohen, S., Campbell, R., Karmiloff-Smith, A., Grant, J., & Walker, J. (2000). Are Children with Autism Blind to the Mentalistic Significance of the Eyes? *British Journal of Developmental Psychology,13,* 379-398.

Baron-Cohen, S., Wheelwright, S., Skinner, S., Martin, J., & Clubley, E. (2001). The Autism Spectrum Quotient (AQ). Evidence from Asperger Syndrome/High Functioning Autism, Males and Females, Scientists and Mathematicians. *Journal of Autism and Developmental Disorders, 31*, 5-17.

Baron-Cohen, S. (2002).The Extreme Male Brain Theory of Autism.*Trends in Cognitive Sciences, 6,* 248-254.

Baron-Cohen, S. (2005).*The Empathising System: A Revision of the 1994 Model of the Mindreading System*. In B. Ellis & D. Bjorklund (Eds.), Origins of the Social Mind. Guilford: Guilford Publications Inc.

Baron-Cohen, R. A., Hoekstra, R., Knickmeyer, R. C., & Wheelwright, S. (2006). The Autism-Spectrum Quotient (AQ) Adolescent Version. *Journal of Autism and Developmental Disorders 36*, 343-350.

Bartholomous, B. (1973). Voice Identification by Nursery School Children.*Canadian Journal of Psychology, 27,* 464-472.

Bayliss, A. P., Pellegrino, G., & Tipper, S. P. (2005).Sex Differences in Eye Gaze and Symbolic Cueing of Attention. *The Quarterly Journal of Experimental Psychology, 58*, 631-650.

Bayliss, A. P., & Tipper S. P. (2005). Gaze and Arrow Cueing of Attention Reveals Individual Differences along the Autism-Spectrum as a Function of Target Context. *British Journal of Psychology*, *96*, 95–114.

Beauchamp, M. S., Lee, K. E., Haxby, J. V., & Martin, A. (2002). Parallel Visual Motions Processing Streams for Manipulable Objects and Human Movements.*Neuron, 34,* 149–159.

Beauchamp, M. S., Lee, K. E., Haxby, J. V., & Martin, N. (2003). fMRI Responses to Video and Point-Light Displays of Moving Humans and Manipulable Objects. *Journal of Cognitive Neuroscience, 15,* 991-1001.

Blair, R. J., Frith, U., Smith, N., Abel, F., & Cipolotti, L. (2001). Fractionation of Visual Memory: Agency Detection and its Impairment in Autism. *Neuropsychologia, 40,* 108-118.

Blake, R., Turner, L. M., Smoski, M. J., Pozdol, S. L., & Stone, W. L. (2003). Visual Recognition of Biological Motion in Impaired Children with Autism. *Psychological Science, 14,* 151-157.

Blakemore, S. J., &Decety, J. (2001).From the Perception of Action to the Understanding of Intention. *Nature Reviews Neuroscience, 2*, 561-567.

Bleuler, E. (1911). Dementia Praecox or the Group of Schizophrenias. Translated by Zinkin J. New York, International Universities Press, 1950.

Botvinick, M., Jha, A. P., Bylsma, L. M., Fabian, S. A., Solomon P. E., & Prkachin, K. M. (2005). Viewing Facial Expressions of Pain Engages Cortical Areas Involved in the Direct Experience of Pain. *NeuroImage, 25,* 312–319.

Boucher, J., & Lewis, V. (1992). Unfamiliar Face Recognition in Relatively Able Autistic Children. *Journal of child Psychology and Psychiatry*, *35*, 843-859.

Boucher. J., Lewis. V., & Collins, G. (1998). Familiar Face and Voice Matching and Recognition in Children with Autism. *Journal of Child Psychology 39*, 171-181.

Bowler, D. M., & Thommen, E. (2000). Attribution of Mechanical and Social Causality to Animated Displays by Children with Autism. *Autism, 4*, 147-171.

Brambilla, P., Hardan, A., Di Nemi, S. U., Perez, J., Soares, J. C., & Barale, F. (2003). Brain Anatomy and Development in Autism: Review of structural MRI Studies. *Brain Research Bulletin*, *61*, 557–569.

British Psychological Society (BPS) (2001).

Brothers, L. (1990). The Social Brain: A Project for Integrating Primate Behavior and Neurophysiology in a New Domain. *Concepts in Neuroscience, 1,* 27-51.

Bruner, J. (1983).*Child's talk: Learning to use language*. New York: Norton.

Bruner, J., Goodnow, J. J., & Austin, G. A. (1967). A Study of Thinking. New York: Science Editions.

Buitelaar, J. K., Van Engeland, H., De Kogel, K. H., De Vries, H. & Van Hooff, J. A. R. A. M. (1991). Differences in the Structure of Social Behaviour of Autistic Children and Non-Autistic Retarded Controls. *Journal of Child Psychology and Psychiatry, 32,* 995-1015.

Burnett, H., & Jellema, T. (under revision). (Re-)conceptualisation in Asperger's Syndrome and Typical Individuals with Varying Degrees of Autistic-like Traits. *Journal of Autism and Developmental Disorders.*

Byrne, R., & Whiten, A. (1998) *Machiavellian Intelligence, Social Expertise and the Evolution of Intellect in Monkeys Apes, and Humans.* Oxford University Press.

Campbell, R., Baron-Cohen, S., & Walker, J. (1995). Do People with Autism Show a Whole Face Advantage in Recognition of Familiar Faces and Their Parts? A Test of Central Coherence Theory. *Unpublished ms, Goldsmiths College, University of London.*

Carr, E. G., & Durand, V. M. (1985). Reducing Behaviour Problems through Functional Communication Training. *Journal of Applied Behaviour Analysis, 18*, 111-126.

Castelli, F., Frith, C., Happe, F., & Frith, U. (2002). Autism, Asperger Syndrome and Brain Mechanisms for the Attribution of Mental States to Animated Shapes. *Brain*, *125,* 1839-1849.

Cesaroni, L., & Garber, M. (1991).Exploring the Experience of Autism through First-Hand Accounts. *Journal of Autism and Developmental Disorders, 21,* 303-201.

Chakrabarti, S., & Fombonne, E. (2005). Pervasive Developmental Disorders in Preschool Children: Confirmation of High Prevalence. *American Journal of Psychiatry, 162*, 1133-1141.

Chao, L. L., Weisberg, J., & Martin, A. (2002). Experience-dependent modulation of category-related cortical activity. *Cerebral Cortex, 12,* 545-551.

Charman, T., Swettenham, J., Baron-Cohen, S., Cox, A., Baird, G., & Drew, A. (1997). Infants with Autism: An Investigation of Empathy, Pretend Play, Joint Attention and Imitation. *Developmental Psychology, 33,* 781-789.

Cheng, Y., Yang, C. Y., Lin, C. P., Lee, P. R., & Decety, J. (2008). The Perception of Pain in Others Suppresses Somatosensory Oscillations: A Magnetoencephalography Study". *NeuroImage, 40,*1833–1840.

Cipolotti, L., Robinson, G., Blair, J., & Frith, U. (1999). Fractionation of Visual Memory: Evidence from a Case with Multiple Neurodevelopmental Impairments. *Neuropsychologia,37*, 455-465.

Courchesne, E. (1987). A Neurophysiological View of Autism. *In E. Schoper &*

G.B. Mesibow (Eds.), Neurobiological Issues in Autism (pp.285-324). New York Press.

Courchesne, E., Yeung-Courchesne, R., Press, G.A., Hesselink, J. R., & Jernigan, T. L. (1988). Hypoplasia of Cerebellum Vermal Lobules V1 and VII in Autism. *New England Journal of Medicine 318*, 1349-1354.

Courchesne, E. (1989). Neuroanatomical Systems Involved in Infantile Autism: The Implications of Cerebellar Abnormalities.*In G. Dawson (Eds.) Autism: New Perspectives on Diagnosis, Nature and Treatment (pp.119-14*3). New York: Guilford Press.

Courchesne, E., Townsend, J., Akshoomoff, N. A., Saitoh, O., Yeung-Courchesne, R., Lincoln, A. J., James, H. E., Haas, R. H., Schreibman, L., & Lau, L. (1994a). Impairment in Shifting Attention in Autistic and Cerebellum Patients. *Behavioural Neuroscience*, *108,* 848-865.

Courchesne, E., Townsend, J. P., & Saitoh, O. (1994b). The Brain in Early Infantile Autism: Posterior Fossa Structures are Abnormal. *Neurology, 44,* 214-223.

Courchesne, E., Chisum, H., & Townsend, J. (1995). Neural Activity Dependent Brain Changes in Development: Implications for Psychopathology. *Development and Psychopathology, 6,* 697–722.

Cowley, G. (1995). Blind to Other Minds. *Newsweek*, August 14, p67.

Cox, A., Klein, K., Charman, T., Baird, G., Baron-Cohen, S., Swettenham, J., Drew, A., & Wheelwright, S. (1999). Autism Spectrum Disorders at 20 and 42 Months of Age: Stability of Clinical and ADI-R Diagnosis. *Journal of Child Psychology and Psychiatry, 40*, 719–732.

Crouch, J. A., Greve, K. W., & Brooks, J. (1996). The California Card Sorting Test may Dissociate Verbal and Non-Verbal Concept Formation Abilities. *British Journal of Clinical Psychology, 35,* 431-434.

Curcio, F. (1978). Sensory Motor Functioning and Communication in Mute Autistic Children.*Journal of Autism and Childhood Schizophrenia, 8,* 281-292.

Dapretto, M., Davies, M. S., Pfeifer, J. H., Scott, A. A., Sigman, M., Bookheimer, S. Y., & Iacoboni, M. (2006). Understanding Emotions in Others: Mirror Neuron Dysfunction in Children with Autism Spectrum Disorders. *Nature Neuroscience, 9,* 28-30.

Davies, S., Bishop, D., Manstead, A. S. R., & Tantam, D. (1994). Face Perception in Children with Autism and Asperger's Syndrome. *Journal of Child Psychology and Psychiatry, 35,* 1033–1057.

Dawson, G., & Fernald, M. (1987). Perspective-Taking Ability and its Relationship to the Social Behaviour of Autistic Children. *Journal of Autism and Developmental Disorders, 17,* 487–498.

Dawson, G., & Lewy, A. (1989).Arousal, Attention and the Socioemotional Impairments of Individuals with Autism *(pp 49-74)*. In G. Sawson (Ed.), *Autism; Nature, Diagnosis And Treatment,* New York; Gilford Press.

Dawson, G., Meltzoff, A. N., Ostering, J., Rinaldi, J., & Brown, E. (1998). Children with Autism Fail to Orient to Naturally Occurring Stimuli. *Journal of Autism and Developmental Disorders, 28*, 479-485.

Dawson, G. (1991). A Psychobiological Perspective on the Early Socio-Emotional Development of Children with Autism. In Sloth & D. Cicchetti (Eds.), *Rochester Symposium on Developmental Psychopathology,* 3, 207-234. Hillsdale, NJ: Erlbaum.

Decety, J. (1996). The Neurophysiological Basis of Motor Imagery. *Behavioural Brain Research, 77,* 45-52.

Delis, D. C., Kaplan, E., & Kramer, J. H. (2001).The Delis–Kaplan Executive Function System. San Antonio: Psychological Corporation.

Dennett, D. (1987). *The Intentional Stance.* MIT Press.

Deruelle, C., Rondan, C., Gepner, B., & Tardif, C. (2004). Spatial Frequency and Face Processing in Children with Autism and Asperger Syndrome. *Journal of Autism and Developmental Disorders, 34,* 199-210.

D'Esposito, M., Detre, J. A., Alsop, D. C., Shin, R. K., Atlas, S., & Crossman, M. (1995). The Neural Basis of the Central Executive System of Working Memory. *Nature, 378,* 279-281.

De Winter, J., & Wagemans, J. (2004). Contour-Based Object Identification and Segmentation: Stimuli, Norms and Data, and Software Tools. *Behaviour Research Methods Instruments & Computers*, *36,* 604-624.

Diagnostic and Statistical Manual of Mental Disorders Four (DSM-IV, 2004.) American Psychiatric Association.

Di Pellegrino, G., Fadiga, L., Fogassi, L., Gallese, V., & Rizzolatti, G. (1992). Understanding Motor Events: a Neurophysiological Study. *Experimental Brain Research, 91*, 176-180.

Downing, P. E., Bray, D., Rogers, J., & Childs, C. (2004). Bodies Capture Attention when Nothing is Expected. *Cognition*, *93,* 27-38.

Dunbar, R. (1998). The Social Brain Hypothesis. *Evolutionary Anthropology*, *6*, 178-190.

Ellis, H. D. (1990). Developmental Trends in Face Recognition. *The Psychologist, 3,* 114-119.

Ehlers, S,.Nyden, A,. Gillberg, C,. Sandberg, A. D,. Dahlgren, S. O,.Hjelmquist, E,. & Oden, A. (1997) Asperger Syndrome, Autism and Attention Disorders: A Comparative Study of the Cognitive Profile of 120 Children. *Journal of Child Psychology and Psychiatry, 38,* 207 – 217.

Ekman, P.,& Friesen, W. V. (1975). *L'nmasking the Face: A Guide to Recognising Emotions from Facial Clues.* Englewood Cliffs, NJ: Prentice-Hall.

Fadiga, L., Fogassi, L., Pavesi, G., & Rizzolatti, G. (1995). Motor Facilitation during Action Observation: A Magnetic Stimulation Study. *Journal of Neurophysiology 73,* 2608–2611.

Fogassi, L., Ferrari, F., Gesierich, B., Rozzi, S., Chersi, F., & Rizzolatti, G. (2005). Parietal Lobe: From Action Organization to Intention Understanding". *Science, 308,* 662–667.

Frith, U. (1989). *Autism: Explaining the Enigma.* Oxford: Blackwell.

Frith, U., Morton, J., & Leslie, A. M. (1991). The Cognitive Basis of a Biological

Disorder – Autism. *Trends in Neurosciences, 14,* 433-438.

Frith, C. D., & Frith, U. (1999). Interacting Minds: A Biological Basis. *Science 286,* 1692-1695.

Frith, U. (2001). Mind Blindness and the Brain in Autism. *Neuron, 32,* 969-979.

Frith, U. (2003). *Autism: Explaining the Enigma*. Oxford: Blackwell Publishing.

Fuggetta, G., Rizzo, S., Pobric, G., Lavidor, M., & Walsh, V. (2009). Functional Representation of Living and Nonliving Domains across the Cerebral Hemispheres: A Combined Event-Related Potential/Transcranial Magnetic Stimulation Study. *Journal of Cognitive Neuroscience, 21*, 403- 414.

Gallese, V., & Goldman, A. (1998). Mirror neurons and the Simulation Theory of Mind-Reading. *Trends in Cognitive Sciences, 2*, 493-501.

Gallese, V., Fadiga, L., Fogassi, L., & Rizzolatti, G. (1996). Action recognition in the premotor cortex. *Brain, 119*, 593-609.

Geurts, H. M., Verte, S., Oosterlaan, J., Roeyers, H., & Sergent, J. A. (2004). How Specific are Executive Functioning Deficits in Attention Deficit Hyperactivity Disorder in Autism? *Child Psychology and Psychiatry, 45,* 836-854.

Geurts, H. M., Corbett, B., & Solomon, M. (2009).*The Paradox of Cognitive Flexibility in Autism. Trends in Cognitive Science, 13*, 74-82.

Gillberg, I.C., & C. Gillberg (1989). Asperger Syndrome- some Epidemiological Considerations: A Research Note. *Journal of Child Psychology and Psychiatry, 30*, 631-638.

Gillberg, C. (1995). Clinical Child Neuropsychiatry, Cambridge: Cambridge University Press.

Goldman, A. (2006). *Simulating Minds: The Philosophy, Psychology and Neuroscience of Mindreading.* New York: Oxford University Press.

Gomot, M., Belmonte, M., Bullmore, E., Bernard, F., & Baron-Cohen, S. (2008). Brain Hyper-Reactivity to Auditory Novel Targets in Children with High-Functioning Autism. *Brain, 131,* 2479-2488.

Geurts, H. M., Verte, S., Oosterlaan, J., Roeyers, H., & Sergent, J. A. (2004). How Specific are Executive Functioning Deficits in Attention Deficit Hyperactivity Disorder in Autism? *Child Psychology and Psychiatry, 45,* 836-854.

Grandin, T. (1995).*Thinking in pictures,* New York*:* Doubleday Publisher.

Hainline, L. (1978). Developmental Changes in Visual Scanning of Face and Non-Face Patterns by Infants. *Journal of Experimental Child Psychology, 25,* 90-115.

Happé, F. (1999) Autism: Cognitive Deficit or Cognitive Style?.*Trends in Cognitive Sciences, 3,* 216-222.

Happé, F., & Frith, U. (2006). The Weak Coherence Account: Detail-Focused Cognitive Style in Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders, 36,* 5-25.

Hermelin, B., & O'Connor, N. (1967). Perceptual and Motor Discrimination in Psychotic and Normal Children. *Journal of Genetic Psychology, 110,* 117-125.

Hill, E., & Frith, U. (2003).Understanding Autism: Insights from Mind and Brain. *Philosophical Transactions: Biological Sciences, 358*, 281-289.

Hill, E. (2004). Evaluating the Theory of Executive Dysfunction in Autism. *Developmental Review, 24,* 189-233.

Hill, E., & Bird, C. M. (2006). Executive Processes in Asperger Syndrome: Patterns of Performance in a Multiple Case Series. *Neuropsychologia, 44*, 2822-2835.

Hirai, M., Hiraki, K. (2005) An Event-Related Potential Study of Biological Motion Perception in Human Infants. *Cognitive Brain Research*, *22,* 301-304.

Hobson, P. R. (1987). The Autistic Child's Recognition of Age and Sex Related Characteristics of People. *Journal of Autism and Developmental Disorders, 17,* 63-69.

Hobson, R. P. (1993). *Autism and the Development of Mind.* Lawrence Erlbaum Associates Ltd., Pub. East Sussex

Hock, H. S., Kelso, J. A. S., & Schoner, G. (1993). Bistability and Hysteresis in the Organization of Apparent Motion Patterns. *Journal of Experimental*

*Psychology: Human Perception and Performa*nce, *19*, 63-80.

Hoekstra, R. A., Bartels, M., Cath, D. C., & Boomsma, D. I. (2008), Factor Structure, Reliability and Criterion Validity of the Autism-Spectrum Quotient (AQ): A Study in Dutch Population and Patient Groups. *Journal of Autism and Developmental Disorders,* 38, 1555-1566

Hood, B. M. & Atkinson, J. (1993).Disengaging Visual Attention in the Infant and Adult. *Infant Behaviour and Development, 16,* 403-422.

Horng, L. I. (2003). An Adaptive Smoothing Approach for Fitting Digital Planar Curves with Line Segments and Circular Arcs. *Pattern Recognition Letters, 24,* 565–577.

Hughes, C., & Russell, J. (1993). Autistic Children's Difficulty with Mental Disengagement from an Object: Its Implications for Theories of Autism. *Developmental Psychology, 29,* 498-510.

Hughes, C., Russell, J., & Robbins, T. W. (1994). Evidence for Executive Dysfunction in Autism. *Neuropsychologia, 32*, 47–92.

Hurley, S., & Chater, N. (2005).*Perspectives on Imitation: From Neuroscience to Social Science*, Cambridge, MA: MIT Press.

Iacoboni, M., & Dapretto, M. (2006) The Mirror Neuron System and the Consequence of it's Dysfunction. *Nature, 7,* 942-951.

Jellema, T., & Perrett, D. I. (2002).Coding of Visible and Hidden Objects. *Attention and Performance, 19,* 356-380.

Jellema, T., & Perrett, D. I. (2003). Cells in Monkey STS that are Responsive to Articulated Body Motions and Consequent Static Posture: A Case of Implied Motion? *Neuropsychologia, 4,*1728-1737.

Jellema, T., & Perrett, D. I. (2005). Neural Basis for the Perception of Goal-Directed Actions. In A. Easton and N. J. Emery (Eds.).*The Cognitive Neuroscience of Social Behaviour*. Psychology Press, New York. Studies in Cognition Series, 81-112.

Jellema, T.,& Perrett, D. I. (2007). Neural Pathways of Social Cognition. In: *The Oxford Handbook of Evolutionary Psychology* (R. I. M. Dunbar & L. Barrett, Eds), Oxford University Press. pp163-177.

Jellema, T., Lorteije, J. A. M., Van Rijn S., Van 't Wout, M., De Haan, E. H. F., Van Engeland, H., & Kemner,C. (2009). Involuntary Processing of Social Cues is Compromised in Autism Spectrum Disorders. *Autism Research,2*, 192-204.

Johnson, M. H., Posner, M. I., & Rothbart, M. K. (1991). Components of Visual Orienting in Early Infancy: Contingency Learning, Anticipating, Looking, and Disengaging. *Journal of Cognitive Neuroscience, 3,* 335-344.

Johnson, C. R., & Rakinson, D. H. (2006). Early Categorization of Animate/ Inanimate Concepts in Young Children with Autism. *Journal of Developmental and Physical Disabilities, 18,* 73-89.

Jolliffe, T., & Baron-Cohen, S. (1997). Are People with Autism and Asperger Syndrome Faster than Normal on the Embedded Figures Test? *Journal of Child Psychology and Psychiatry, 38,* 527-534.

Kanwisher, N., Woods, R.P., Iacoboni, M., & Mazziotta, J. C. (1997). A Locus in Human Extrastriate Cortex for Visual Shape Analysis. *Journal of Cognitive Neuroscience, 9,* 133-142.

Kaland, N., Smith, L., & Mortensen, E, L. (2008). Brief Report: Cognitive Flexibility And Focused Attention in Children and Adolescents with Aspergers Syndrome or High Functioning Autism as Measured on the Computerised Version of the Wisconsin Card Sorting Test. *Journal of Autism Developmental Disorders, 38*, 1161-1165.

Kanner.L. (1943).Autistic disturbances of affective contact. The *Nervous Child, 2*, 217–250.

Kanner, L., & Lesser, L. I. (1958).Early Infantile Autism. *Paediatrics Clinic of North America, 5*,711-730.

Kleinhans, N., Akshoomoff, N., & Delis, D. C., (2005). Executive Functions in Autism and Asperger's Disorder, Flexibility, Fluency, and Inhibition.

Developmental Neuropsychology, 27, 379-401.

Koegel, L. K. (1995). *Communication and Language Intervention.* In R. L. Koegel & L. K. Koegel (Eds.), *Teaching Children with Autism: Strategies for Initiating Positive Interactions and Improving Learning Opportunities*. Baltimore: Brookes.

Kučera, H., & Francis, W. N. (1967).*Computational Analysis of Present Day American English.* Providence, R. I.: Brown University Press.

Lamm, C., Batson, C. D., & Decety, J. (2007). The Neural Substrate of Human Empathy: Effects of Perspective-Taking and Cognitive Appraisal. *Journal of Cognitive Neuroscience,19,* 42–58.

Landry, R., & Bryson, S. E. (2004). Impaired Disengagement of Attention in Young Children with Autism. *Journal of Child Psychology and Psychiatry*, *45,* 1115-1122.

Langdell, T. (1978). Recognition of Faces: An Approach to the Study of Autism. *Journal of Child Psychology and Psychiatry, 19,* 255–268.

Leekan, S., Baron-Cohen, S., Perrett, D., Milders, M., & Brown, S. (1993). Eye Direction Detection: A Dissociation between Geometric and Joint Attentional Skills in Autism.Unpublished Manuscript.Institute of Social Psychology. University of Kent. In Mindblindness*: An Essay on Autism and Theory of Mind.* MIT Press: Baron-Cohen, S. 1995.

Lord, C., Rutter, M., DiLavore, P. C., & Risi, S. (1999). *Autism Diagnostic Observation Schedule*. Los Angeles, CA: Western Psychological Services.

Lothman, D.F., Hagen, E.P., Thorndike, R.L. (1995). *The Cognitive Abilities Test 3 (CAT-3), British Education.* Windsor: NFER-Nelson.

Loveland, K., & Landry, S. (1986). Joint Attention and Language in Autism on Developmental Language Delay. *Journal of Autism and Developmental Disorders, 16,* 335-349.

Macintosh, K., & Dissanayke, C. (2004). The Similarities and Differences between

Autistic Disorder and Asperger's Disorder; A Review of Empirical Evidence. *Journal of Child Psychology and Psychiatry, 45,* 421-434.

Malatesta, C. Z., & Haviland, J. M. (1982). Learning Display Rules: The Socialization of Emotion Expressions in Infancy. *Child Development, 53*, 991–1003.

Mattila, M. L., Kielinen, M., Jussila, K., Linna, S. L., Bloigu, R., & Ebeling, H. (2007). An Epidemiological and Diagnostic Study of Asperger Syndrome According to Four Sets of Diagnostic Criteria. *Journal of the American Academy of Child and Adolescent Psychiatry, 46*, 636-646.

McCarthy, G., Pruce, A., Gore, J. C., & Allison, T., (1997). Face-Specific Processing in the Human Fusiform Gyrus. *Journal of Cognitive Neuroscience, 9,* 605-610.

Miller, E. K., & Cohen, J. D. (2002). An Integrative Theory of Prefrontal Cortex Function. *Annual Review Neuroscience, 24,* 167–202.

Milner, B. (1964a). Effect of Different Brain Lesions on Card Sorting. *Archives of Neurology, 9,* 90-100.

Milner, B. (1964b). Some Effects of Frontal Lobotomy in Man. *In J. Warren & K.A. Kert (eds)*. The Frontal Granular Cortex and Behaviour. New York: McGraur-Hill.

Minshew, N., Siegel, D., Goldstein, G., & Weldy, S. (1994). Verbal Problem Solving in High Functioning Autistic Individuals. *Archives of Clinical Neuropsychology, 9*, 31-40.

Minshew, N. J., Meyer, J., & Goldstein, G. (2002) Abstract Reasoning in Autism: A Disassociation between Concept Formation and Concept Identification. *Neuropsychology,16,* 327-334.

Mundy, P., Sigman, Ungerere, J., & Sherman, T. (1986). Defining the Social Deficits of Autism: The Contribution of Non-verbal Communication Measures. *Journal of Child Psychology and Psychiatry & Allied Disciplines, 27,* 657-669.

Nordin, V., & Gillberg, C. (1998). The Long-Term Course of Autistic Disorders: Update on Follow-up Studies*. ActaPsychiatricaScandinavica 97,* 99-108

Oberman, L. M., Hubbard, E. M., McCleery, J. P., Altschuler, E. L., Ramachandran, V. S., & Pineda, J. A. (2005). EEG Evidence for Mirror Neuron Dysfunction in Autism Spectrum Disorders. *Cognitive Brain Research,24,* 190–198.

Osterling, J., & Dawson, G. (1994). Early Recognition of Children with Autism: A Study of First Birthday Home Videotapes. *Journal of Autism and Developmental Disorders,24,* 247–257.

Oram, M. W., & Perrett, D. I. (1996). Integration of Form and Motion in the Anterior Superior Temporal Polysensory Area (STPa) of the Macaque Monkey. *Journal of Neurophysiology, 76,* 109–1297.

Ozonoff, S., Pennington, B., & Rogers, S. (1991). Executive Function Deficits in High Functioning Autistic Children: Relationship to Theory of Mind. *Journal of Child Psychology and Psychiatry, 32,* 1081-1106.

Ozonoff, S., & McEvoy, R. (1994). A longitudinal study of executive function and theory of mind development in autism, *Development and Psychopathology, 6,* 415–431.

Ozonoff, S. (1995). Reliability and Validity of the Wisconsin Card Sorting Test in Studies of Autism, *Neuropsychology, 9,* 491-500.

Ozonoff, S., & Strayer, D. L. (1997). Inhibitory function in non-retarded children with autism. *Journal of Autism and Developmental Disorders, 27,* 59–77.

Ozonoff, S., & Jensen, J. (1999). Brief Report: Specific Executive Function Profiles in Three Neurodevelopmental Disorders. *Journal of Autism and Developmental Disorders, 29,* 171-177.

Ozonoff, S., South, M., & Miller, J. N. (2000). DSM-IV Defined Asperger Syndrome: Cognitive, Behavioural and Early History Differentiation from High Functioning Autism. *Autism, 4,* 29-46.

Pascualvaca, D. M., Fantie, B. D., Papageorgiou, M., & Mirsky, A. F. (1998). Attentional Capacities in Children with Autism; Is There a General Deficit in Shifting Focus?. *Journal of autism and developmental disorders, 28,* 467-478.

Peirce, K., Gland, K. S., & Schreibman, L. (1997). Social Perception in Children with

Autism: An Attentional Deficit? Journal *of Autism and Developmental Disorders, 27*, 265-282.

Pellicano, E., Gibson, L., Maybery, M., Durkin, K., & Badcock. (2005). Abnormal Processing along the Dorsal Visual Pathway in Autism: A Possible Mechanism for Weak Visuospatial Coherence?,*Neuropsychologia, 43,* 1044-1053.

Pellicano, E. (2006). Links between Theory of Mind and Executive Function in Young Children with Autism: Clues to Developmental Primacy. *Developmental Psychology, 43*, 974-990.

Pellicano, E. (2007) 'Links between Theory of Mind and Executive Function in Young Children with Autism: Clues to Developmental Primacy', *Developmental Psychology,* 43, 974-990.

Pellis, S. M., & Pellis, V. C. (2006).*Play and the Development of Social Engagement: A Comparative Perspective.* In: P. J. Marshall & N. A. Fox, (Eds.), The Development of Social Engagement: Neurobiological Perspectives *(pp. 247-274).*Oxford University Press; Oxford, UK.

Perret, E. (1974). The Left Frontal Lobe of Man and the Suppression of Habitual Responses in Verbal Categorical Behaviour. *Neuropsychologia,12,* 323–330.

Perrett, D. I., Harries, M. H., Bevan, R., Thomas, S., Benson, P. J., Mistlin, A. J., Chitty, A. J., Hietanen, J. K., & Ortega, J. E. (1989). Frameworks of Analysis for the Neural Representation of Animate Objects and Actions. *Journal of Experimental Biology,146,* 87–113.

Peterson, C. C., & Siegal, M. (2000). Insights into Theory of Mind from Deafness and Autism. *Mind and Language, 15*, 77–99.

Plaisted, K., O'Riordan, M., & Baron-Cohen, S. (1998). Enhanced Visual Search for a Conjunctive Target in Autism. *Journal of Child Psychology and Psychiatry, 39,* 777-783.

Plaisted, K., Swettenham, J., & Rees, L. (1999). Children with Autism show Local

Precedence in a Divided Attention Task and Global in a Selective Attention Task.*Journal of Child Psychology and Psychiatry, 5,* 733-742.

Pratt, C., & Bryant, P. (1990). Young Children Understand that Looking Leads to Knowing (So Long as They are Looking into a Single Barrel). *Child Development, 61,* 973-982.

Ratkinson, D. H., &Poulin-Dubois, D. (2001). Developmental Origin of the Animate-Inanimate Distinction. *Psychological Bulletin, 127,* 209-228.

Reber, A. S. (1995).*The Penguin Dictionary of Psychology*. 2nd Ed. London, England: Penguin.

Reddy, V. (1991). Playing with Others Expectations: Teasing and Mucking About in the First Year. *In Natural Theories of Mind,* ed. A. Whiten. Blackwell.

Rhinehart, N. J., Bradshaw, J. L., Moss, S. A., Berley, A. V., & Tange, B. J. (2001). A Deficit in Shifting Attention Present in High Functioning Autism but not Asperger's Syndrome, *Autism, 5,* 67-80.

Rincover, A., & Ducharme, J. M. (1987). Variables Affecting Stimulus Overselectivity and 'Tunnel Vision' in Developmentally Delayed Children. *American Journal of Mental Deficiency, 91,* 422-430.

Rimland, B. (1964). *Infantile autism.* New York: Appleton- Crofts.

Ritvo, E. R. & Freeman, B. J. (1978). National Society for Autistic Children Definition of the Syndrome of Autism. *Journal of Autism and Childhood Schizophrenia, 8,* 162-67.

Rizzolatti, G., Fadiga, L., Gallese, V., & Fogassi, L. (1996).Premotor cortex and the recognition of motor actions. *Cognitive Brain Research, 3*, 131-141.

Rizzolatti, G., Fogassi, L., & Gallese, V. (2001). Neurophysiological Mechanisms Underlying the Understanding and Imitation of Action. *Nature Neuroscience Reviews* 2: 661–670.

Rizzolatti, G., & Craighero, L. (2004).The Mirror-Neuron System. *Annual Review of Neuroscience, 27,* 169–192.

Rizzolatti, G., & Sinigaglia, C. (2008). Mirrors *in the Brain: How do Our Minds*

Share Actions, Emotions and Experience?. Oxford University Press: London.

Robin, E., McEvoy, R. E., Rogers, S. J., & Pennington, B. F. (2006).*Executive Function and Social Communication Deficits in Young Autistic Children. Journal of Child Psychology and Psychiatry, 34,* 563-578.

Ropar, D., Mitchell, P. & Ackroyd, K. (2003) 'Do Children with Autism Find it Difficult to Offer Alternative Interpretations to Ambiguous Figures?' *British Journal of Developmental Psychology,* 21, 387–395.

Rumsey, J. M. (1985). Conceptual Problem Solving Ability in Highly Verbal, Non-Retarded Autistic Men. *Journal of Autism and Developmental Disorders, 15,* 23-36.

Rumsey, J. M., & Hamburger, S. D. (1988). Neurophysiological Findings in High Functioning Men with Infantile Autism, Residual State. *Journal of Clinical Experimental Neuropsychology,10,* 201-221.

Russell, J. (1998). *Autism as an Executive Disorder.* Oxford University Press.

Russell, J., Jarold, C., &Hood, B. (1999a). Two Intact Executive Capacities in Children with Autism: Implications for the Core Executive Dysfunctions in the Disorder. *Journal of Autism and Developmental Disorders*, *29,* 103-112.

Russell, J., Jarrold, C., & Hood, B. (1999b). Implications for the Core Executive Dysfunctions in the Disorder. *Journal of Autism and Developmental Disorder, 29,* 103-112.

Rutherford, M. D., Pennington, B. P., & Rogers, S. J. (2006). The Perception of Animacy in Young Children with Autism. *Journal of Developmental Disorders, 36,* 983-992.

Rutter, M., & Schopler, E. (1987). Autism and Pervasive Developmental Disorders: Concepts and Diagnostic Issues. *Journal of Autism and Developmental Disorders,* 17, 159-186.

Rutter, M. (1978).Diagnosis and Definition of Childhood Autism. *Journal of Autism and Developmental Disorders 8*, 139-161.

Scassellati, B. (2000). Theory of Mind for a Humanoid Robot. Paper Presented at The First IEEE/RAS International Conference on Humanoid Robotics.

Scharre, J. E., & Creedon, M. P. (1992). Assessment of Visual Function in Autistic Children. *Optometry and Visual Science,* 69, 433-439.

Scott, J., Clark, C., & Brady, M. P. (2000).*Students with Autism: Characteristics and Instructional Programming for Special Educators.* San Diego: Singular.

Senju, A., Southgate, V., White, S., & Frith, U. (2009). Mindblind Eyes: An Absence of Spontaneous Theory of Mind in Asperger Syndrome. *Science, 325*, 883-885.

Shah, A., & Frith, U. (1983). Why do Autistic Individuals Show Superior Performance on the Block Design Task? *Journal of Child Psychology and Psychiatry, 34*, 1351-1364.

Shah, A., & Frith, U. (1993). Why do Autistic Individuals Show Superior Performance on the Block Design Task?. *Journal of Child Psychology and Psychiatry, 34,* 1351-1364.

Shallice, T. (1982).Specific Impairments of Planning. *Philosophical Transactions of the Royal Society of London B*, *298*, 199-209.

Snodgrass, J. G., & Van der Wart, M. (1980). A Standardized Set of 260 Pictures: Norms for Name Agreement, Image Agreement, Familiarity, and Visual Complexity. *Journal of Experimental Psychology: Human Learning and Memory, 6,* 174-215.

Sobel, D.M., Capps, L.M., & Gopnik, A. (2005) ‘Ambiguous Figure Perception and Theory of Mind Understanding in Children with Autistic Spectrum Disorders’, *British Journal of Developmental Psychology* 23, 159–174.

Sohn, M., Ursa, S., Anderson, J. R., Stenger, V. A., & Carter, C. S. (2000). The Role of Prefrontal Cortex and Posterior Parietal Cortex in Task Switching. *Proceedings of the National Academy of Sciences, 97, 13448-13453.*

Spencer, J., O’Brien, J., Riggs, K., Braddick, O., Atkinson, J., & Wattam-Bell, J. (2000). Motion Processing in Autism: Evidence for a Dorsal Stream

Deficiency. *Neuroreport, 11,* 2765-2767.

Stuss, D. T., & Benson, D. F. (1986). *The Frontal Lobes.* New York: Raven Press.

Sundberg, M. L., & Partington, J. W. (1998).*Teaching Language to Children with Autism and Other Developmental Disabilities.* Pleasant Hill, CA: Behavior Analysts, Inc.

Swettenham, J., Baron-Cohen, S., Charman, T., Cox, A., Baird, G., Drew, A., Rees, L. (1998). The Frequency and Distribution of Spontaneous Attention Shifts between Social and Nonsocial Stimuli in Autistic, Typically Developing, and Non-Autistic Developmentally Delayed Infants. *Journal of Child Psychology and Psychiatry, 39,* 747-753.

Tager-Flusberg, H. (1993). What Language Reveals about the Understanding of Minds in Children with Autism. *In Understanding Other Minds: Perspectives from Autism,* ed. S. Baron-Cohen et al. Oxford University Press.

Tager-Flusberg, H. & Sullivan, K. (1995). Attributing Mental States to Story Characters: A Comparison of Narratives Produced by Autistic and Mentally Retarded Individuals. *Applied Psycholinguistics, 16,* 241-256.

Tomasello, M., (1988). The Role of Joint Attentional Processes in Early Language Acquisition. *Language Sciences, 10,* 69-88

Tsuchiya, E., Oki, J., Yahara, N., & Fujieda, K. (2004). Computerised Version of the Wisconsin Card Sorting Test in Children with High Functioning Autistic Disorder or Attention Deficit/Hyperactivity Disorder. *Brain and Development, 27*, 233-236.

Tulving, E., Markowitsch, H. J., Crakk, F. I. M., Habib, R., & Houle, S. (1996). Novelty and Familiarity Activations in PET Studies of Memory Encoding and Retrieval. *Cerebebal Cortex 6, 71–79.*

Van 'tWout, M., Van Rijn, S., Jellema, T., Kahn, R. S., & Aleman, A. (2009). Deficits in Implicit Attention to Social Signals in Schizophrenia and High Risk Groups: Behavioural Evidence from a New Illusion. *PLoS ONE, 4,* e5581, 1-9.

Van Eylen, L., Boets, B., Steyaert, J., Evers, K., Wagemans, J., & Noens, I. (2011).

Cognitive Flexibility in Autism Spectrum Disorder: Explaining the Inconsistencies? *Research in Autism Spectrum Disorders, 5,* 1390–1401.

Venter, A., Lord, C., & Schopler, E. (1992). A Follow-Up Study of High-Functioning Autistic Children. *Journal of Child Psychology and Psychiatry 33,* 489–507.

Verbeke, E., Peeters, W., Kerkhof, I., Bijttebier, P., Steyaert, J., & Wagemans, J. (2005). Lack of Motivation to Share Intentions: Primary Deficit in Autism? *Behavioral and Brain Sciences, 28,* 718-719.

Vecera, S. P., & Johnson, M. H. (1995). Gaze Detection and the Cortical Processing of Faces: Evidence from Infants and Adults. *Visual Cognition, 2,* 59-87.

Verstijnen, I. M., & Wagemans, J. (2004). Ambiguous Figures: Living Versus Nonliving Objects. *Perception, 33,* 531-546

Volkmar, F. R., Lord, C., Bailey, A., Schultz, R. T., & Klin, A. (2004).Autism and Pervasive Disorders. *Journal of Child Psychology and Psychiatry, 45,* 135-170.

Wakabayashi, A, Baron-Cohen, S., Wheelwright, S., & Tojo, Y. (2006). The Autism-Spectrum Quotient (AQ) in Japan: A Cross-Cultural Comparison. *Journal of Autism and Developmental Disorders, 31*, 5-17.

Warrington, E. K., & Shallice, T. (1984). Category Specific Semantic Impairments, Brain, 107, 829-854.

Wechsler, D. (1991). *Wechsler Intelligence Scale for Children* (3rd ed.). New York: Psychological Corp.

Wechsler, D. (1997). WAIS-III: Wechsler Adult Intelligence Scale–Third Edition: Administration and Scoring Manual, The Psychological Corporation, San Antonio, TX.

Whatmough, C., Chertkow, H., Murtha, S., & Hanratty, K. (2002). Dissociable Brain Regions Process Object Meaning and Object Structure During Picture Naming. *Neuropsychologia, 40*, 174-186.

Wheatly, T., Milleville, S. C., & Martin, A. (2007). Understanding Animate Agents:

Distinct Roles for the Social Network and Mirror System. *Psychological Science, 18*, 469-474.

Wheelwright, S., Baron-Cohen, S., Goldenfeld, N., Delaney, J., Fine, D., Smith, R., Weil, L., & Wakabayahsi, A. (2006). Predicting Autism Spectrum Quotient (AQ) from the Systemizing Quotient-Revised (SQ-R) and Empathy Quotient (EQ).*Brain Research,1079,* 47-56.

Wiggett, J., Pritchard, I. C., & Downing, P. E. (2009). Animate and Inanimate Objects in Human Visual Cortex: Evidence for Task-Independent Category Effects. *Neuropsychologia, 47,* 3111-3117.

Wilson, A.D., Plumb, M., Williams, J. H. G., & Mon-Williams, M. (2006) 'Sticky Attention' in Autistic Spectrum Disorder--Visual Psychophysics and Movement. *Perception, 35* (ECVP Abstract Supplement), 132.

Wimmer, H., &Perner, J. (1983). Beliefs about beliefs: Representation and Constraining Function of Wrong Beliefs in Young Children's Understanding of Deception. *Cognition, 13,* 103-128.

Williams, J. H. G., Whiten, A., Suddendorf, T., & Perrett, D. I. (2001). Imitation, Mirror Neurons and Autism. *Neuroscience and Behavioural Reviews, 25*, 287-295.

Williams, J. H. G., Waiter, G. D., Gilchrist, A., Perrett, D. I., Murray, A. D., & Whiten, A. (2005). Neural Mechanisms of Imitation and 'Mirror Neuron' Functioning in Autistic Spectrum Disorder. *Neuropsychologia, 44,* 610-621.

Wilson, A. D., Plumb, M., Williams, J. H. G., & Mon-Williams, M. A. (2006). Sticky Attention in Autistic Spectrum Disorder-Visual Psychophysics and Movement. *Perception (EVCP Abstract.), 35,* 132.

Wing, L. (1993). The Definition and Prevalence of Autism: A review. *European Child and Adolescent Psychiatry, 2,* 61-74.

Wing, L. & Gould, J. (1979). Severe Impairments of Social Interaction and Associated Abnormalities in Children: Epidemiology and Classification. *Journal of Autism and Developmental Disorders, 9*, 11-29.

Woods, J., & Wetherby, A. (2003).Early Identification and Intervention for Infants and Toddlers who are at Risk for ASD. *Language, Speech and Hearing Services in the School, 34*, 180-193.

World Health Organization (1992). The ICD–10 Classification of Diseases Clinical Descriptions and Diagnostic Guidelines. Geneva: WHO

Wright, I., Strand, S., & Wonders, S. (2005) Estimation of Pre-morbid Intellectual Abilities in Children. *Education and Child Psychology, 22,* 100-107.

Yeates, K. O., & Taylor, H. G. (1997). Predicting Pre-morbid Neuropsychological Functioning following Paediatric Traumatic Brain Injury. *Journal of Clinical and Experimental Neuropsychology, 19*, 825-837.

Zakian, A., Malvy, J., Desombre, H., Roux, S., & Lenoir, P. (2000). Early Signs of Autism and Family Films: A New Study by Informed Evaluators and Those Unaware of the Diagnosis. *L'Encephale, 26,* 38-44.

Zilbovicius, M., Meresse, I., Chabane, N., Brunelle, F., Samson, Y., & Boddaert, N. (2006). Autism, the superior temporal sulcus and social perception. *Trends in Neurosciences, 29*, 359-366.

Appendix 1. ***The Autism Diagnostic Observation Schedule (ADOS)***

Module 3: Administration

1. Construction task*
2. Make Believe play
3. Joint interactive play
4. Demonstration task*
5. Description of a picture*
6. Telling a story from a book*
7. Cartoons*
8. Conversation and Reporting*
9. Emotions*
10. Social difficulties and annoyance*
11. Break*
12. Friends and Marriage*
13. Loneliness*
14. Creating a story*

**These tasks are also administered in Module 4*

Module 4: Administration

*All tasks marked in Module 3 and ...

15. Daily living
16. Plans and hopes

The tasks involved in modules 3 and 4 are described as follows;

1. The Construction task

The focus of this observation is to help the participant feel comfortable in the situation with the examiner. Provide the examiner the opportunity to observe whether the participant indicates that they need more pieces i.e. do they ask, reach for examiners arm, provide eye contact facial expression and gesture.

2. Make believe play

The focus of this observation is to observe the extent to which the participant produces a sequence of actions that involve using materials beyond their most obvious intention. Also to look at how the participant cast the dolls as animate beings and pretend that they are interacting with each other.

3. Joint interactive play

The focus of the observation is the reciprocity shown by the participant in interactive play. The goal for the participant is to develop interaction and to provide a novel initiative that goes beyond a direct response to the examiners overtures.

4. Demonstration task

The goal of the task is to determine if and how the participant represents familiar actions in gesture, particularly through the use of his/her body to represent an object (e.g. a finger for a toothbrush) or miming the use of a pretend object. In addition the examiner should consider the extent to which the participant can a) appropriately modify the level of detail to the context at hand and b) report about the familiar event.

5. Description of a picture

The goal of this task is to obtain an example of the participants spontaneous language and communication, as well as a sense of what captures his/her interest.

6. Telling a story from a book

The goal of this task like the pretending one, is to obtain an example of the participants spontaneous language and communication as well as a sense of what captures his/her interest. The task also provides an opportunity to evaluate participant's response to conventional humour and his/her understanding of visual indications of social context (e.g. what the characters are doing and how they are feeling)

7. Cartoons

The goal of this task is to include a) observation of the participants use of gesture and its coordination with speech and b) further observation of the participants response to humour c) taking additional language sample and d) obtaining a sense of his/her degree of insight and flexibility in adapting a narrative to an audience of the listener and e) noting any comments he/she might make about affect and relationships.

8. Conversation and reporting

The focus of the observation is the extent to which the participant builds on the examiners statements and takes full role in back and forth conversation particularly how the participant reports non-routine and routine events and how he/she describes relationships and emotions. The task also affords opportunity to observe the participants communication including his/her use of eye gaze, facial expression intonation and gesture.

9. Emotions

The focus of the observation is a) to identify what events/objects illicit different emotions in the participant, particularly whether they are social or not b) to observe how the participant describes his/her emotions.

10. Social difficulties and annoyance

The focus of this observation is the participants perception of social difficulties and insights into the nature of these problems and whether he/she has made any attempt to change his/her behaviour in order to fit in with others more smoothly. Attention should be made to the participants understanding of appropriateness and implications of his/her feelings.

11. Break

The focus of the break is to observe a) how the participant occupies themselves in free time b) how they respond to the examiners withdrawal from interaction c) how the participant initiates and participates in an unstructured conversation or interaction with the examiner.

12. Friends and marriage

The focus of this item is not to see if the participant has friends but to see if they understand the concept of friendship/marriage/relationships and their own role in these interactions. The questions relating to marriage are to observe the participants understanding of why a person may want to be part of a long term relationship and his/her own possible role in such a relationship.

13. Loneliness

These questions are to address whether the participant understands the concept of loneliness and how he/she feels in pertains to him/her

14.Creating a story

The focus of the observation is to observe the participants creative use of telling a novel story or creating a newscast or commercial.

15.Daily living

These questions provide a) factual information about the participants level of understanding of responsibility b) establish where he/she is living and how this arrangement was arrived at

c) indicate the extent to which the participant is realistic about plans for independence and the complexities of living arrangements d) to see how the participant manages their free time and how they manage money.

16. Plans and hopes

This question is intended to provide a positive end to the interview and obtain information about what the participant anticipates for the future.

Coding

Coding is integrally related to the administration of the ADOS. Codes rely on operational definitions, which are the ways in which behaviours are defined for the purpose of coding. There are various types of codes on the ADOS. Some are based on behaviours that occurred throughout the schedule. These include codes on behaviours such as gestures, eye contact and affect. There are other behaviours that are linked to specific items such as response to joint attention, imagination and creativity.

Algorithms

Using codes from the protocol, the examiner completes an algorithm, all 3's become 2's and all 7's become 8's and 9's become 0's. Codes of '0' indicate that the participant displays a appropriate level for the behaviour specified, '1' indicates an abnormal or inappropriate behaviour to less a severity than the score of '2'. After transferring the codes on the algorithm page, the items are summarised into 1) Communication Items, 2) Reciprocal Social Interaction Items, 3) TOTAL of 1+2, 4)Imagination and Creativity, 5) Stereotyped Behaviours and Restricted Interests. The examiner then checks to see if the participant meets the autism or ASD criteria.

- *Communication Total*

Autism cut off = 3

Autism Spectrum cut off = 2

- *Social Interaction Total*

  Autism cut off = 6

  Autism Spectrum cut off = 4

- *Communication and Social Interaction Total*

  Autism cut off = 10

  Autism Spectrum cut off = 7