SOCIAL MOTIVATION IN PEOPLE WITH AND WITHOUT AUTISM SPECTRUM DISORDERS

BY INDU DUBEY

THESIS SUBMITTED TO THE UNIVERSITY OF NOTTINGHAM FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

JULY 2016

ABSTRACT

It is commonly observed that people with autism spectrum disorder (ASD) make fewer attempts to have social contact. A recent theory suggests that reduced motivation to have social interactions might be the root for social difficulties in ASD (Chevallier, Kohls, Troiani, Brodkin, & Schultz, 2012). There are currently few simple behavioural ways to test these claims. The aim of this research was 1) to develop a measure of social seeking component of social motivation that is simple enough to be used with a large population of people with ASD; and 2) to test if there is evidence of reduced social seeking in people with ASD.

As the first part of this research, I developed and tested a simple behavioural paradigm "Choose-A-Movie" (CAM) that evaluates the effort participants make to view social vs non-social stimuli hence estimating the reward value of the stimuli. It was found that typical adults prefer to watch social stimuli more but they trade-off their stimuli preference for effort. In experiment 2 I used the same paradigm with adults with and without ASD and found that unlike typical adults people with ASD prefer non-social stimuli but they too trade-off their stimuli preference for effort.

Having established the efficacy of the CAM paradigm in adults with and without ASD, in experiment 3 I explored CAM's efficacy for younger participants. A comparison between adolescents with and without ASD on CAM showed that both groups prefer choice requiring less effort, and participants with ASD prefer non-social stimuli to social. However unlike typical adults, typical adolescents did not show a preference for social stimuli. Though these experiments supported the reduced social motivation theory of ASD, they raised

questions about the development of social seeking in typical people. Therefore, in experiment 4 I tested participants between ages 4-20 years on CAM. The results showed that typical individuals undergo a decline in their social seeking tendencies during pre-adolescence. This highlights the need for developmental evaluation of social seeking in both ASD and non-ASD populations.

Finally, in experiment 5 the CAM paradigm was compared with an Approach-avoidance (AA) task, a frequently used measure of social seeking (Aharon et al., 2001). The findings suggested that social preference could be elicited more strongly in typical adults using CAM paradigm. Furthermore the autistic traits of participants were a reliable predictor of social seeking on CAM but not on AA task. These results raise the question of whether different tools claiming to measure social seeking target the same behaviour.

Overall, this research shows that social motivation can be quantified using a simple behavioural paradigm – CAM that targets social seeking component of it, and also that social motivation is reduced in people with ASD. At the same time this research raises important questions about 1) developmental changes in social seeking in typical people, and 2) if different tools of social seeking, measure the same underlying construct. It is important to explore these questions to have a better understanding of social seeking in people with ASD.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my supervisors Danielle Ropar and Richard Tunney and my advisor Antonia Hamilton for their continuous support, guidance, and inspiration through this PhD. Throughout this process they gave me opportunities to discuss my ideas and provided constructive feedback to develop those into meaningful research questions. They not only helped me develop research skills but also grow as a person. I could not have imagined having better mentors for my PhD research.

My sincere thanks also go to past and present members of Autism Research Team and Human Development and Learning group - Alastair Smith, Lucy Cragg, Shiri Einav, Harry Purser, Elizabeth Sheppard, Peter Mitchell, Lauren Marsh, Amy Pearson, Katie Greenfield, Danielle Smith, and Jennifer Tellett, who provided feedback at every stage of my research. Their support enriched this work and made this difficult journey enjoyable.

I am grateful to all the participants, schools, parents, and attendees of summer scientist week events who made this research possible.

Last, but not the least, I would like to thank my husband, Zia for always being there not only as partner who encouraged me to take up this endeavour, but also as a colleague who asked the most pertinent questions about my work. I would also like to thank my parents, in-laws, siblings, and friends – Dilnaz, Katie and Kathleen for their support throughout this PhD and my life in general. Last but not the least I would like to thank my son Arsh who was my closest companion while writing and defending this work.

TABLE OF CONTENTS

Chapter 4. Adolescents with Autism Show Low Social Preference but Typical Adolescents Show No Preference

Chapter 5. Social Motivation Declines during Preadolescence

ABBREVIATIONS

AA: Approach-Avoidance

AQ: Autism Quotient

BPVS: British Picture Vocabulary Scale

CAM: Choose-A-Movie

MID: Monetary Incentive Delay

RPM: Raven's Progressive Matrices

SAS: Social Aptitude Scale

SID: Social Incentive Delay

SRS: Social Responsiveness Scale

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: GENERAL INTRODUCTION

Humans have evolved complex social behaviour that governs their lives. For instance they seek social affiliations and cooperate with each other to live in groups (Baumeister & Leary, 1995). As evolutionary theory suggests this is not a coincidence but the need to be in the groups emerges from the fact that early humans could not survive alone as they needed to cooperate with each other to hunt or gather food successfully. Therefore, historically social interactions have a strong survival value for humans. Though, with time the methods of social interactions have changes, yet we still spend good amount of time and effort in socializing. The wide use of social networking websites, clubs, and social gatherings suggests that social interactions may serve other higher cognitive needs. There are significant individual differences in the extent to which people choose to spend their time socialising. These differences form a spectrum, while some people might have a strong need for socialising; others might fall on the other end of spectrum, displaying characteristics such as social aloofness. Autism Spectrum Disorders (ASD) is one of such conditions in which people may fall more towards the aloof side of this spectrum.

The drive for social interactions is a subjective experience and is hard to be evaluated objectively. The aim of this thesis is to develop a method that can be used to objectively measure social motivation in people of different ages and cognitive abilities both with and without ASD. In this chapter, I will discuss: The role of social interactions in early and later years of life, social differences in autism spectrum disorders (ASD), and evaluate the theories explaining these differences. Within the theories, I will focus primarily on the recently proposed

theory of reduced social motivation in ASD and explore the evidence of social motivation in typical and ASD groups. At the end I will evaluate the methods used to measure the social seeking component of social motivation theory.

1.1 Social development at early years of life

Human offspring are dependent on their caregiver for a long time before they can survive on their own. Social behaviour such as crying in distress, cooing, smiling and imitating, serve as primary tools for them to attract attention of capable adults to ensure that they are protected and fed (Nakayama, 2015). A study with six month old infants shows that when presented facial stimuli among other non-social objects, infants direct their first saccades to faces more frequently than chance (Gliga, Elsabbagh, Andravizou, & Johnson, 2009). This suggests that social stimuli might have a special status for infants resulting in automatic priming for social interactions. Another study with three, six and nine month old infants demonstrated that a preference for social stimuli such as face or face-like displays, increases with improvement in the attentional abilities of infants (Frank, Amso, & Johnson, 2014). A similar increase in a preference for social stimuli was reported by Di Giorgio, Turati, Altoè, and Simion (2012), who tested three and nine month old infants as well as adults. They reported that nine month olds and adults show a strong preference for faces but not the three month olds. Di Giorgio et al emphasised the role of experience with face-like structures in making the social stimuli more salient for older children and adults. However, the possibility of experience influencing the preference for social stimuli is rejected by a study conducted with nine minute old infants (Goren, Sarty, & Wu, 1975) with no visual experience of social stimuli. Goren et al found

that these infants turned their eyes and heads to follow face like stimuli but not for the scrambled control stimuli. The preference for social stimuli in human infants is not limited to the visual domain but has been found in other modalities. Children as young as 1-3 days old orient their head more in response to human than nonhuman voices (Ecklund-Flores & Turkewitz, 1996), 3-7 month olds show a differential activation in temporal cortex when presented with human and non-human voices (Blasi et al., 2011), and 4-6 month olds show a greater preference for biological than non-biological movements (Fox & McDaniel, 1982).

Altogether this evidence suggests that humans are prepared to attend to social information from the environment from a very young age. As discussed in the beginning of this section, the preference for social stimuli in infancy might be for evolutionary purposes to ensure survival, however it is important to know if the need for social interactions changes with the development. To answer this question, in the next section I will discuss if the preference for social stimuli observed in infancy continues to exist or decline during adulthood.

1.2 Social development during adulthood

While early social interactions might facilitate survival, they may also serve as an important means to acquire essential skills, form social bonds and enhance the opportunities for reproduction during later years. Perhaps that is why social interactions are placed as one of the primary needs that motivate our behaviour after biological needs (Maslow, 1943). It has been suggested that adults unconsciously imitate each other's posture, expressions and mannerism to facilitate their social interactions (Chartrand & Bargh, 1999). Like children,

adults too show more rapid processing for social information than non-social, when presented with complex visual stimuli (Fletcher-Watson, Findlay, Leekam, & Benson, 2008). They follow social gaze cues more rapidly even when they are not helpful (Driver et al., 1999). They express higher liking for objects that are gazed upon by other people (Bayliss, Paul, Cannon, & Tipper, 2006), perhaps because prolonged gaze of another person is seen as an indicator of higher value of the object. Like infants, adults also show differential brain activation for human voices over non-human (Belin, Zatorre, Lafaille, Ahad, & Pike, 2000), and have specialized sensitivity to recognise emotions through human voices (Morris, Scott, & Dolan, 1999). The specialised ability to identify social information might be an essential step for social affiliations during adulthood, increasing chances of procreation and formations of larger societies. Healthy social attachments are also linked to overall better adjustment and quality of life (Baumeister & Leary, 1995).

The above discussion suggests that social stimuli have special value for both infants as well as adults. Though the nature and underlying reasons might differ across development, but typically developing people are generally motivated to seek social contact. However, there is also great variability in regards to how much social interaction people prefer. While some people like to make several friends and spend longer time in social activities, others prefer fewer social contacts and solo activities. While spending time on one's own can be important, a strong desire to refrain from social interactions can have consequences on the development of social skills and quality of life. Autism spectrum disorders (ASD) is a clinical condition in which difficulty with social interaction and communication are a core diagnostic feature. In the next section

I will discuss the social difference in ASD and proposed theories to understand them.

1.3 Difference in social functioning in autism spectrum disorders

The diagnostic criteria from Diagnostic Statistical Manual (DSM) 5 describes “persistent deficits in social communication and social interaction across contexts” as the major diagnostic feature of ASD (American Psychiatric Association, 2013). This includes lack of initiation of social interactions, abnormal social approach, difficulty having back and forth interactions, etc. Difficulty in social interactions as described by “qualitative abnormalities in reciprocal social interaction” is also included in the International Classification of Disease (ICD) 10 criteria for diagnosis of ASD (World Health Organisation, 1992). As ASD is a spectrum disorder social difficulties can vary from severe to mild across individuals. While in some individuals social difficulties can be seen in basic skills such as pre-language communication behaviours like ‘pointing’, ‘joint attention’ etc. in others it might be with more complex social behaviour such as difficulty in having reciprocal social interactions. Importantly, the social difficulties in ASD are not simply a result of limited cognitive abilities, as even adults with ASD having average/higher cognitive abilities also struggle with social demands (Simon Baron-Cohen, 1988; Loveland & Landry, 1986).

Early research exploring social difficulties in ASD carried out by Wing and Gould (1979) suggested three social subtypes: 1) aloof- this group shows no desire to have any social interactions and cannot be engaged for long in interactions initiated by others; 2) passive- this group does not make initiative

to have social interactions, however can engage in brief social interactions if approached by others; 3) odd but active- this group shows strong social approach behaviour and makes initiative to have interactions, however they may lack the skills to maintain social interaction for the interest of self as well as others. Though most individuals with ASD can be assigned to one of these social subtypes, their social difficulties might change depending on the interpersonal demands. Some individuals might progress from being more aloof to passive or from passive to odd with time (Simon Baron-Cohen, 1988). The underlying causes of these social difficulties in ASD are not precisely known but researchers have proposed different theories to understand them. Some theories emphasize the role of cognitive functions in the development of social skills. In the next section I will briefly describe some of the cognitive theories proposed to understand social difficulties in ASD.

1.3.1 Theories of social difficulties in ASD

There are 3 main theories which have attempted to explain social difficulties in ASD. These are: Theory of mind, weak central coherence, and executive function deficits in ASD. I will discuss these theories in relation to social difficulties in ASD.

1.3.1.1 ***Theory of mind****:* The first of these theories, *"Theory of Mind"* (TOM) proposes that the primary cause of social difficulties in ASD might be a deficit in understanding what other people think, believe, and feel. Theory of mind is an essential tool to navigate through social situations. Typical children might start to develop this ability as young as 7 months of age (Kovacs, Teglas, & Endress, 2010) and by 3 years of age they can demonstrate some

understanding of other's intentions (Call & Tomasello, 1998). By age 4-6 years children develop a good understanding of others intentions, beliefs and feelings (Frith & Frith, 2003). The ability to use theory of mind keeps developing until late adolescence (Dumontheil, Apperly, & Blakemore, 2010). Deficits in the ability to understand others beliefs and intentions is seen as a major factor influencing deficits in social functioning in several clinical conditions such as psychosis (Healey, Penn, Perkins, Woods, & Addington, 2013), schizophrenia (Brüne, 2003), social anxiety (Hezel & McNally, 2014), and ASD (Baron-Cohen, Leslie & Frith, 1985). There is evidence that ToM might be delayed in ASD (Tager-Flusberg, 2007). Delayed development of theory of mind may result in difficulties with joint attention, understanding others gaze, and following pretend play (Charman et al., 1997). It also affects the ability to understand family and peer interactions (Peterson, Garnett, Kelly, & Attwood, 2009) and cooperativeness (Paal & Bereczkei, 2007). However, there is evidence that children with ASD might show poor empathic understanding and difficulty in social behaviour, even when they perform well on explicit tests of theory of mind (Aldridge, Stone, Sweeney, & Bower, 2000; Carpenter, Pennington, & Rogers, 2001; Peterson, 2014). This indicates that not all social difficulties can be attributed to deficits in theory of mind. Hobson (1993) believed that social development of children starts long before they acquire theory of mind. Therefore he argues that impairment in emotional processing is the basis of deficits associated with social-cognitive development. Klin, Jones, Schultz, and Volkmar (2003) further elaborated on this idea as theory of *enactive mind* (EM), in which they emphasised the role of affective and pre-dispositional responses to social situations in socialisation. They suggested that typical children's minds are predisposed to undergo interactive adaptations to make sense of social

environment that changes constantly, however children with ASD might not be predisposed to deal with the social environment which results in later social difficulties like poor ability to understand what others are thinking of feeling.

***1.3.1.2 Deficits in executive functions*:** As the name suggests this theory proposed to understand core features of ASD focusing on d*eficits in executive functions* (Ozonoff, Pennington, & Rogers, 1991). Executive functions involve a number of skills including forward planning, inhibition, and attention switching. The ability to inhibit a spontaneous reaction, generate alternatives and modulate responses in social situations are an essential element of social interactions. Any deficit in executive function may thus result in social difficulties. It is also suggested that children who exhibit better executive functions are better able to inhibit salient information, make decisions based on the evaluation of all options, and are more likely to engage in prosocial and cooperative behaviour which are essential building blocks for long term social relations (Moore, Barresi, & Thompson, 1998). However, Perner and Lang (2013) argued that the ability to mentally represent something is an essential element of executive function therefore presence of theory of mind plays a crucial role in the executive function and perhaps developmentally precede the development of executive functions. Furthermore the role of executive function deficits in social – communicative deficits has been challenged by White (2013). She suggests that the deficits observed in people with ASD on the tasks of executive function might be due to a lack of clear instructions and an inability to read the mind of the examiner rather than executive dysfunction (White, 2013).

1.3.1.3 Weak central coherence*:* Another theory proposed to understand social difficulties in ASD suggests that people with ASD might focus more on details, and fail to integrate small parts into a meaningful whole. This theory which was initially proposed by Uta Frith in 1989 is referred to as *weak central coherence* (Frith, 1989 as cited in Happe, 1997). This theory also explains why individuals with ASD may be overly literal as they do not take context into account when interpreting ambiguous language. People with ASD when presented with a task requiring integration of words and context to reach an inference, fail to perform similarly to a matched control group (Jolliffe & Baron-Cohen, 1999). It is further suggested that even if a person has intact theory of mind he needs to have intact ability to integrate information from various sources and contexts to understand another persons' mental state, therefore weak central coherence might be an important factor influencing social behaviour of people with ASD (Happé, 1997). However, Li, Zhu, Liu, and Li (2014) explored the cooperative behaviour in people with ASD using theories of theory of mind (TOM), weak central coherence (WCC), and executive functions. They found that cooperativeness in ASD could be predicted through the measures of TOM and executive functions but not the measures of central coherence. These findings hence indicate that social behaviour like cooperation might require different mental abilities than the ability to integrate information from various sources. Furthermore, Berger, Aerts, Spaendonck, Cools, and Teunisse (2003) on a three year-long intervention study with adults with ASD, showed that poor weak central coherence was not a reliable predictor of social improvement. This evidence suggests that weak central coherence might not be able to explain all social difficulties in ASD.

The cognitive theories discussed above help us to understand how various cognitive skills such as metacognition, central coherence and executive functions can influence social behaviour. Therefore it might appear that they can also provide a strong base for understanding differences in social behaviours observed in ASD. However, a study by Joseph & Tager–Flusberg (2004) shows that deficits in theory of mind and executive functions might be able to explain the variability in the language based symptoms of ASD but they cannot sufficiently explain the variability in the social functioning of ASD. There is also evidence that some individuals with ASD can pass TOM and executive function tests, but still show difficulties with empathy and social interaction (Aldridge et al 2000; Carpenter et al., 2001; Joseph & Tager–Flusberg, 2004). Carr (2007) argued that although the cognitive skills required for social interactions can be taught to people with ASD, if they lack motivation to engage with others, they might use the skills only functionally rather than socially. For example, a child who is trained to make eye-contact may look towards the eyes of another person but not use the social cues conveyed through the eyes. This idea is supported by the evidence from studies showing that interventions targeting these cognitive areas report little improvement in everyday social communication skills (Begeer et al., 2011; Diamond & Lee, 2011). This suggests that an individual must not only have the relevant cognitive skills but also to be able to use them spontaneously and appropriately implying problems at a motivational level.

In the next section I will discuss why the above discussed theories are inefficient in explaining the subgroups of social difficulties in ASD and how reduced social motivation theory might be able to fill in that gap.

1.3.2 Why we need more theories?

Symptoms such as communication difficulties and stereotypical behaviour in ASD tend to improve with age however social difficulties remain a major cause of concern even in adulthood for both low and high functioning people with ASD (Seltzer, Shattuck, Abbeduto, & Greenberg, 2004; Shattuck et al., 2007; Starr, Szatmari, Bryson, & Zwaigenbaum, 2003). The most commonly used intervention technique used to help social difficulties in ASD is social skill training (Reichow, Steiner, & Volkmar, 2012). Social skill training focuses on developing social competence by using behavioural principles of modelling, role plays, reinforcements and feedbacks (Reichow et al., 2012). Social skill training which is based primarily on cognitive theories aims to help people with ASD learn "rules" of social interaction, such as turn taking, appropriate eye-gaze, and reading emotions of others. A recent review based on 66 studies presenting data of 513 participants suggests that social skills training and video modelling can be classified as evidence based interventions that show improvement in the target skills. However these interventions fail to show generalisation of skills learned in the laboratory to daily life (Reichow & Volkmar, 2010). Even though people with ASD learn the essential skills required for social interactions they may not use them in their regular daily life environment. The reason for poor generalisation of skills might lie in the low motivation to engage in the target activity. Motivation is the result of internal experience of emotion that pushes organism to engage in certain behaviour to seek comfort or pleasure. Recently the role of 'motivation' in influencing social development is emphasised as a determinant of social behaviour. The theory of reduced social motivation is proposed to understand the variability in the social interaction difficulties in ASD

(Chevallier, Kohls, et al., 2012). In the next section I will discuss various components and evidence for this theory in detail.

1.4 Reduced Social Motivation in ASD

The idea that difficulty in experiencing emotions might be the root of deficits in social development in ASD was suggested by Kanner (1943) who studied 11 children and proposed that they show a different kind of emotional condition which he described as *"inability to form the usual, biologically provided affective contacts with people, just as other children come into the world with innate physical or intellectual handicaps*." (p. 250). He proposed it to be the "*inborn autistic disturbance of affective contact*" (p. 250). Other researchers also propose that a deficit in motivation to engage with others might result in a clinical manifestation of social behavioural difficulties (Koegel & Mentis, 1985).

The desire to socially engage with others is a complex internal state which is difficult to evaluate objectively (Brody, 1980). It can influence our behaviour in subtle forms which is hard to understand even by the person who is influenced (Brody, 1980). While some researchers exploring social engagement in ASD, define it as an ability to identify and orient to social stimuli in the environment (Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998), others see it as a subtle underlying force that can explain the complex social behaviour of self-presentation and impression management (Geen, 1991). Recently Chevallier, Kohls, et al (2012) put these concepts together and proposed a comprehensive theory of social motivation. They divide social motivation in three components: 1) social orientation, the ability to identify

socially relevant cues from the environment 2) social maintenance, the continuation of social interaction for a long duration, and 3) social seeking, the behavioural effort made to engage in social interactions that have been pleasurable in the past. They also suggested that reduced social motivation might be an important factor influencing social difficulties in ASD. In the following sections I will discuss these three components of social motivation theory while evaluating: the concept, efficacy of the methods used to measure them, and the evidence of their presence/differences in typical and ASD groups.

1.4.1 Social orientation

Social orientation is conceptualised as the ability to detect the available social cues from the environment. It is suggested that our brain is optimized to identify the stimuli that can promote survival which is registered as being rewarding (Seitz, Kim, & Watanabe, 2009). Therefore automatic visual orientation to a social or non-social stimulus can suggests its rewarding value for people (Anderson, Laurent, & Yantis, 2011). Evidence for social orientation has been shown through the visual priority for faces (Gliga & Csibra, 2007; Johnson, Dziurawiec, Ellis, & Morton, 1991), faster reaction time to identify social stimuli, reflexive shift of attention to follow gaze direction (Hill et al., 2010), longer fixations for biological movement (Klin, Shultz, & Jones, 2015).

1.4.1.1. ***Measures of social orientation:*** Social Orientation is often measured using eye tracking techniques (Frank, Vul, & Johnson, 2009; Libertus & Needham, 2011). The technique was introduced by Yarbus (1967) to measure the eye movements in relation to the presented stimuli. Eye tracking is an excellent tool to provide an objective measure of visual attention of the

participants (Clarke, 1996). Yarbus (1967) claimed that eyes “fixate on those elements of an object which carry or may carry essential or useful information” (p. 211). The studies exploring social orientation therefore record the first saccade or the overall duration of fixation toward region of interest of the stimuli to measure the value of the stimuli. Studies using eye-tracking have used a range of stimuli including simple static images to complex social scenes or videos. Though generally eye tracking techniques are used in laboratory settings, some researchers have used it in natural settings with mobile eye trackers (Freeth, Foulsham, & Kingstone, 2013). These eye trackers provide more ecologically valid visual fixation patterns of participants. Eye tracking techniques have also been used in combination with virtual reality to explore the relationship between eye-gaze and approach – avoidance behaviour (Bailenson, Blascovich, & Guadagno, 2008).

Eye tracking can be used to measure different components of social motivation, such as the evaluation of first saccade can be a good measure of social orientation on the other hand the duration of visual fixation might be a good measure of the liking for the stimuli, which is the second component of social motivation (discussed in section 1.4.3). In this section eye-tracking method is primarily discussed in context of social orientation, which focuses on automatic prioritization of social stimuli in a complex environment.

Social orientation has also been evaluated in adults by measuring the reaction time in a change detection paradigm, in which participants responded to any change in the image of either social (i.e. female faces) or non-social (i.e. appliance, cloths, plants etc.) categories (Ro, Russell, & Lavie, 2001).

Though eye tracking or change detection are sophisticated tools to measure social orientation, it is difficult to use them with infants and new-borns.

Therefore some researchers use head movement to track visual orienting responses in infants. They used head mounted cameras that can track the movement of the child as he explores the world (Schmitow & Stenberg, 2015). This technique allows one to explore a child's visual orientation in real life social interactions and has the potential for giving a unique understanding of children's visual attention in their social world, although it is less precise than eye-tracking.

1.4.1.2 ***Social orientation in typical population*****:** Research using eye tracking techniques in typical infants suggests that when presented with social (i.e. female faces with direct eye gaze), and non-social (i.e. shoes, cars) images, infants attend to the social images much faster (Di Giorgio et al., 2012; Gliga et al., 2009; Gluckman & Johnson, 2013). Similar findings have been reported for typical adults in a free viewing task (Fletcher-Watson et al., 2008). When presented with natural scenes (images) with and without social stimuli, typical adults tend to attend to the social stimuli much quicker than non-social, and also spend much longer looking at the social stimuli than non-social background. A study using an electrooculography (EOG) method has also been used with the typical adults to measure the saccadic reaction time for social orientation (Tomalski, Csibra, & Johnson, 2009). This technique is based on the potential (electrical) difference between cornea and retina giving a precise measure of eye movement (Heide, Koenig, Trillenberg, Kompf, & Zee, 1999). The findings from Tomalski, Csibra, and Johnson's study corroborate the previous findings showing faster eye movements for face like schematic stimuli. Social orientation measured in typical participants using change detection paradigm showed that the reaction time to detect changes in social stimuli is

much faster than non-social stimuli, indicating a special status for faces of typical people (Ro et al., 2001).

Behavioural observation and quantification of spontaneous attention to social or non-social stimuli is the least intrusive measure of social orientation. Goren et al (1975) used this method with new-borns 9 minutes after birth. The infants were shown moving images of faces, scrambled faces or a blanks screen and their eye and head movements were compared to the infants' initial nose position in terms of degree of rotation. The results showed that even these infants with hardly any prior experience of the social world had a stronger responsiveness to faces. Another observation based study carried out by Maestro et al (2005) analysed home videos of children to explore social orienting behaviour. The results showed that typical children spontaneously attend to the social stimuli in their environment significantly more than non-social stimuli.

In sum, these studies involving different methods and participants from infancy through adulthood, show that typical people have a specialised preference for social stimuli in their environment. These stimuli have a special status from a very young age indicating an evolved preference for social orientation in typical people. In the next section I will discuss the studies that aimed to explore social preference in people with ASD.

1.4.1.*3 Social orientation in ASD population:* Like typical groups social orientation has been evaluated using various methods in people with ASD. Eye-tracking techniques are also used regularly to evaluate social orientation in people with ASD. One frequently cited study carried out by Klin, Jones, Schultz, Volkmar, and Cohen (2002) evaluated spontaneous visual

fixation on video clips from movies. They found that people with ASD focus more on non-social information in a scene than a typically developing matched group. Also when presented with only social stimuli such as faces, people with ASD show longer visual fixation for mouth region rather than eye region or they may look at the facial stimuli in a piecemeal fashion rather than as a whole and miss the salient social information (Joseph & Tanaka, 2003; Neumann, Spezio, Piven, & Adolphs, 2006; Speer, Cook, McMahon, & Clark, 2007). Evidence of reduced social orienting has also been found in younger children with ASD. Chawarska, Macari, and Shic (2013) showed that children as young as 6 month old, who were later diagnosed to have ASD, had lower spontaneous visual fixation to the social elements of videos in which a female interacts with everyday toys around the screen.

On the other hand, several studies have failed to find a difference in social orienting in those with and without ASD. Study by Sasson and Touchstone (2014) exploring spontaneous visual attention using eye tracking in 2-5 year old children with ASD, reported that these children were not different in their visual exploration when social images were presented along with regular objects. However, their attention to social stimuli decreased significantly when they were presented with objects of circumscribed interest to autism such as vehicles. Therefore it suggests that lower spontaneous attention to social stimuli might be influenced more by the context (here the nature of the other stimuli) than just simply a lower interest in social stimuli. Evidence of intact visual orienting was also found by Wilson, Brock, & Palermo (2010) who reported that both typical children (10-12 year) and children with ASD show strong bias for social stimuli. Though typical children spent a proportionally longer time looking

at the social elements of a naturalistic scene than non-social, children with ASD did not show any such preference.

Hermelin and O'Connor (1963, as cited in Hermelin & O'Connor, 1970) used behavioural observation in children and recorded if specified social orienting behaviour during observation period. Results of this study showed that children with autism and matched control had no difference in their orienting response to various social and non-social stimuli except one non-social condition of manipulating toys. Another observation method based study carried out by Dawson et al (1998) compared 20 children with ASD, 19 children with Down's syndrome and 20 matched controls. The results from this study showed that children with ASD frequently failed to orient to salient stimuli (i.e. noise of toys etc.), but their response to social stimuli (i.e. calling by name) was more reduced than non-social stimuli (i.e. rattle sound). These findings suggest that children with ASD might show social orientation deficits in the auditory modality as well.

Overall, these findings suggest that while typical people identify and respond to social cues automatically, people with autism might not do this as consistently. This can influence their early social experiences that form the building blocks for later social adjustment. But these studies cannot confirm if the observed difference in ASD is because they attach higher value to the non-social stimuli or if they find social stimuli aversive.

1.4.2 Social maintenance

Social maintenance refers to behaviours which are carried out to strengthen and foster social relationships. People maintain social relations for long time to get most benefit out of them. They try to present a positive image

of themselves, conceal negative emotions, lie and also imitate others to facilitate social interaction (DePaulo & Bell, 1996; DePaulo & Kashy, 1998; Lakin & Chartrand, 2003). Evidence of behavioural efforts to maintain long term social interactions is also seen in children. Children as young as 3 years of age consciously present themselves in a positive light to get acceptance by others (Fu & Lee, 2007; Talwar, Murphy, & Lee, 2007). Imitation is also used to facilitates social acceptance (Charman et al., 2000) and it correlates positively with level of empathy (Chartrand & Bargh, 1999). In the next section, I will discuss the primary methods used to examine behaviours aimed to facilitate social interactions.

1.4.2.1 Measures of social maintenance: Social maintenance is primarily evaluated by exploring social politeness, audience effect and reputation management. This generally involves creating experimental paradigms in which the participant is encouraged to make donations, or rate someone's effort/work etc. Other techniques used for evaluation of social maintenance are behavioural observations and self-reports (Bauminger & Kasari, 2000; Liebal, Colombi, Rogers, Warneken, & Tomasello, 2008; Rekers, Haun, & Tomasello, 2011).

It is believed that people want to be in groups and maintain regular social affiliations, researchers proposed that an experience of discontinuation of social interactions such as rejection or exclusion by other groups members, might cause one to make more effort to reconnect with others (Gardner, Pickett, & Brewer, 2000). Therefore social exclusion has also been used as a method to

measure social maintenance in typical as well as clinical conditions (Levinson, Langer, & Rodebaugh, 2013; Park & Baumeister, 2015).

The methods discussed up until now are laboratory based experimental manipulations. Though very controlled these methods are generally criticised for their limited ecological validity. Michelson, Mannarino, Marchione, Kazdin, and Costello (1985) criticised them for being vulnerable to social desirability bias, as in most of these experiments the participants are aware of being observed, hence it is very likely that they may amend their behaviour to meet what they believe are the expectations of the observer. The alternative methods such as self-reports, questionnaire and interviews, are more direct measures of behaviour under investigation but their validity depends largely on the honesty of the participants. Furthermore these methods too are influenced by social desirability bias (de Reuver & Bouwman, 2014; Donaldson & Grant-Vallone, 2002; Moorman & Podsakoff, 1992). In addition to this the essential underlying assumption of these methods 'an ability to introspect and express one's experience verbally' might make them unsuitable for some clinical conditions (Nisbett & Wilson, 1977) such as ASD which is characterised by difficulties, verbalizing and expressing emotional/internal states (Mazefsky, Kao, & Oswald, 2011). To overcome the limitations of the above discussed methods some researchers used both observation and self-report techniques to understand the overall picture of desire for social interactions in people with and without ASD (Deckers, Roelofs, Muris, & Rinck, 2014). They claim that that the two techniques might present different but complimentary results. In the next section I will discuss some of the research that used these methods either alone or together to understand social maintenance behaviour in typical and ASD populations.

1.4.2.2. Social maintenance in typical population: Humans live in groups, hence cooperation and affiliation are their natural social behaviour rather than unethical selfishness (Haidt, 2007). Evidence suggests that typical adults spontaneously engage in socially desirable and prosocial behaviour such as fair distribution of money even when they are distracted while making the decision (Cornelissen, Dewitte, & Warlop, 2011; Zhong, 2011). The strong desire to please others influences people's conscious behaviour as well. Aharoni and Fridlund (2007) compared behavioural response of people while they were made to believe that the interviewer was either a person or a computer. Results from this study showed that people try to make more effort to appease the interviewer if they believe it is human than non-human. This tendency to please others does not remain limited to "interview" like situations where the participants fears being evaluated, but it also exists in situations where participants are the evaluators. DePaulo and Bell (1996) examined behaviour of typical adults as they evaluated works of art and discussed their liking/disliking with the artists. These adults not only presented positive evaluations but also "lied" about their liking for the paintings, to be polite to the artists. This tendency to see prosocial lie (lies made with intention of helping others) differently from antisocial lies (lies made with intention of harming other) starts as early as 4 years old (Bussey, 1999). Fu and Lee (2007) examined 3-6 years olds on a paradigm smiliar to DePaulo and Bell, and found that older pre-schoolers rated the paintings differently depending on the presence / absence of the painter, hence displaying conscious effort to engage in socially desirable behaviour. Further evidence of a strong need for social affiliation in typical people comes from the studies in which social rejection or exclusion was used

to explore social maintenance behaviour (Derfler-Rozin, Pillutla, & Thau 2010, Park & Baumeister, 2015). These studies suggest that social rejection or exclusion evokes a behavioural response to reciprocate more and engage in behaviours that can re-establish social connections. Having established that typical adults as well as children make conscious attempts to maintain their social interactions by engaging in socially desirable behaviours in this section, I will now discuss if the same is true for people with ASD.

1.4.2.3. Social maintenance in ASD population: Adhering to social norms is an important element of managing social reputation. Therefore any deliberate violation of it is received with surprise by other people. Based on this idea Hobson, Harris, García-Pérez, and Hobson (2009) designed a study to compare surprised reactions to socially awkward situations in children with and without ASD. The study showed that children with ASD did not display any major emotional reaction when the experimenter behaved in a socially inappropriate manner whereas typical children expressed significant surprise. This indicates that engaging in socially approved behaviours to maintain higher reputation might not be valued as much by children with ASD as it is by typical children. Another study used monetary donation in the presence or absence of an audience to explore reputation management. It found that people with ASD though aware of the presence of others were less concerned about managing reputation, as they did not change the amount of donation when observed like typically developing individuals did (Izuma, Matsumoto, Camerer, & Adolphs, 2011). This raises the question of whether children with ASD can comprehend the reciprocal nature of social behaviour that forms the basis of reputation management and prosocial behaviours. To examine this question Cage,

Pellicano, Shah, and Bird, (2013) carried out a study in which participants made the donation in the presence of the others and were told that the observer will make a donation for them at later point of time. The results showed that people with ASD did not make a higher donation while being simply observed but they did so if they believed that the other person would be donating the money for them in the future. This suggests that participants with ASD could understand the reciprocal nature of social relations but were not interested in simple reputation management behaviour. This dissociation between 'intact ability to act' but 'lack of motivation to do so' is also observed in children with ASD. Ingersoll, Schreibman, and Tran (2003) used imitation as a measure of social maintenance in children with ASD and found that these children could imitate others successfully but they would only do it to receive the non-social sensory rewards, not the social rewards.

All of these studies present a strong argument that people with ASD do not lack the ability to understand the effect of their behaviour on others' behaviour, but they may not be willing to behave in certain ways only to form a good social impression. In other words, people with ASD have a lower tendency to engage in social maintenance, which results in less effort to please others, resulting in poor social adjustment.

Investigations of social maintenance in ASD using other methods like self-report and 'social-network' analysis (Chamberlain, Kasari, & Rotheram-Fuller, 2007) and rating scales for quality of friendship (Bauminger & Kasari, 2000) found that despite having lower peer acceptance children with ASD report feeling lonely less. These findings have been recently replicated by Calder, Hill, and Pellicano (2013) who tested 12 children with ASD and their families using self-report questionnaires, observation, parental interview and an exercise to

identify social groups in the classroom. Results showed that children with ASD reported poorer quality of friendships, despite that they reported satisfaction in their social relations. Also the parental reports and observations suggested that though carers provide support for them to have friendships sometimes this might conflict with a child's desire to have these relationships (Calder et al., 2013). Altogether these results support the claims about limited social maintenance and apparent indifference to its impact on social adjustment in ASD.

However along with other well-known limitations such as experimenter induced biases of self-report measures, studies using these methods with people with ASD also face the limitation of being unable to generalise to individuals with ASD having more profound cognitive impairments. Essentially because these individuals might not have the verbal abilities required for these kinds of methods.

On the whole the research on social maintenance suggests that while typical children and adults engage in behaviours that are aimed at increasing their chances of being accepted by others, people with ASD might not do the same. Though they might be aware of the reciprocal nature of social behaviours, they do not tend to engage in them unless there is an immediate need for it. Furthermore, while some people with ASD report having depression which is linked to social difficulties in this group (Kim, Szatmari, Bryson, Streiner, & Wilson, 2000; Matson & Williams, 2014) others, as suggested in the discussion above, may not feel any distress for not having long term social relations. This raises an intriguing question: do some people with ASD not

experience pleasure from typical social interactions leaving them less motivated to take action or do they experience the pleasure but lack the appropriate skills to act. In the next section I will examine the research investigating this question in typical and ASD populations.

1.4.3. Social seeking

There is little doubt that social stimuli have a high reward value for people and that this is related to their social needs. Like other basic rewards, social rewards also have two sub elements: liking and wanting. Liking is the hedonic pleasure derived from a source, whereas wanting is the incentive salience or the reward value that influences an organism to establish contact with the source of that pleasure (Berridge, Robinson, & Aldridge, 2009). In most of the cases wanting and liking are temporally associated as one follows the other. The source of hedonic pleasure serves as an unconditioned stimulus that gets associated with other stimuli (conditioned stimuli) appearing simultaneously or before it. These conditioned stimuli then trigger the anticipatory response in the form of wanting behaviour. Wanting therefore is an anticipatory drive resulting in behavioural actions, which is evoked by a previous pleasant experience.

The ability to experience hedonic pleasure for unconditioned stimuli is innate in humans, but the extent to which it is able to evoke a wanting behaviour might vary depending on the value an individual places on a certain stimulus (Berridge et al., 2009). Contrary to what might appear to be natural, liking for a stimulus might not always results in same level of wanting efforts. Therefore in some cases there is a dissociation between liking and wanting, and it might be important to disentangle them to understand their individual role on behaviours

(Havermans, 2012). However, due to their close temporal association it is very difficult to measure them separately. For this reason most of the researchers measure social seeking as singular concept rather than its separate sub-elements liking or wanting. In this research as well the term social seeking will be used as a singular concept. In the next section I will discuss the most frequently used measure of social seeking in typical and ASD populations.

1.4.3.1 Measure of social seeking: Hess and Polt (1960) proposed that interest or reward value of a stimulus can be evaluated by measuring pupillary dilation in response to it. Nonetheless this proposal was criticised by Hamel, (1974) who argued that pupillary dilation might also be indicator of increased attention due to novelty rather than just reward value.

As discussed above in section 1.4.1. eye tracking techniques are also used to measure social seeking. Though based on visual exploration these techniques are different from pupillary dilation. In this technique participants are presented with various stimuli e.g. array of social and non-social images and the eye-movements of the participants are tracked to measure their duration of fixation on each area of interest. The total duration of fixation on a set of stimuli can be taken as a reliable measure of participant's liking for that stimuli (Chevallier et al., 2015). However like pupillary dilation, eye-tracking too might be influenced by the low level features of the stimuli. For example a participant might spend looking longer at a stimuli because of brightness or contrast of the image rather than its higher reward value for him.

As reward value is a subjective evaluation of expected pleasure, it seems logical that it should be evaluated by taking a subjective report from people. Researchers have used questionnaires or scales to explore desire or

liking for social interactions. Commonly used scales are: scale of behavioural inhibition named as “Behavioural Inhibitory System (BIS)” and scale for behavioural activation named as “Behavioural Activation System (BAS)” (Carver & White, 1994). These scales are based on Gray’s (1981, as cited in Carver & White, 1994) theory of brain functions associated with the aversive motivational system and appetitive motivation. Another tool used for evaluation of social motivation is the “Social Anhedonia Scale” (Reise, Horan, & Blanchard, 2011), which measures lack of interest in social interactions, social aversion, and preference for solitude. However, recently Winkielman (2005) opposed the use of self-report measures by emphasising that the person under investigation might not always be aware of his/her liking for the stimuli, hence subjective report is not the best method of measuring it.

To overcome limitations of self-report measures some researchers have used laboratory based tools to measure social seeking. One of such commonly used method is the Social Incentive Delay task (SID) (see figure 1.1). This task is adapted from the original Monetary Incentive Delay task (MID) (Spreckelmeyer et al., 2009). In the task participants are presented with visual cues such as a circle with lines as shown in figure 1.1. These cues indicate the strength of reward the participant will receive at the end of the trial. The participants are asked to wait for a target (e.g. White Square in the example) and press the key as soon as it appears. Here the reaction time for pressing the key on the appearance of the target is recorded as a measure of seeking motivation for the anticipated reward. In neuroimaging studies using the SID task, strength and location of brain activation during the anticipation phase (waiting for target to appear) is seen as a measure of neural correlates of seeking for the stimulus (Knutson, Westdorp, Kaiser, & Hommer, 2000).

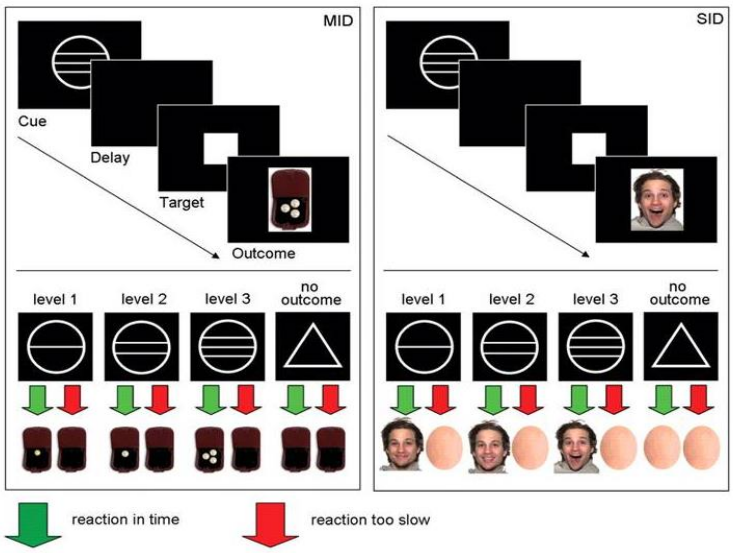

Figure 1.1 Paradigm for the Monetary (MID) and the Social Incentive Delay Task (SID) (Figure taken from Spreckelmeyer et al., 2009).

Another paradigm generally used to measure social seeking is the approach avoidance measure. This task employs the idea that social seeking can be seen as an action of approaching social interactions or avoiding them. The basic paradigm generally involves presenting social images on a computer screen that can be increased/decreased in size by pulling (approaching) or pushing (avoiding) the joystick. The error and reaction time of the approach or avoidance movements are taken as the measure of social seeking (Enter, Spinhoven, & Roelofs, 2014). The same principle of approach and avoidance is also used in some other tasks in which participants are presented with social/non-social images and are encouraged to press a button on a computer keyboard to increase/decrease the duration of presentation of the images on the screen, (Aharon et al., 2001). To make the key presses harder, sometimes researchers use a combination of difficult key presses such as a two button sequence using

the same finger (Aharon et al., 2001; Ewing, Pellicano, & Rhodes, 2013). One such paradigms was used by Hayden, Parikh, Deaner, and Platt (2007) to measure the value of attractive and non-attractive images of people (see figure 1.2).

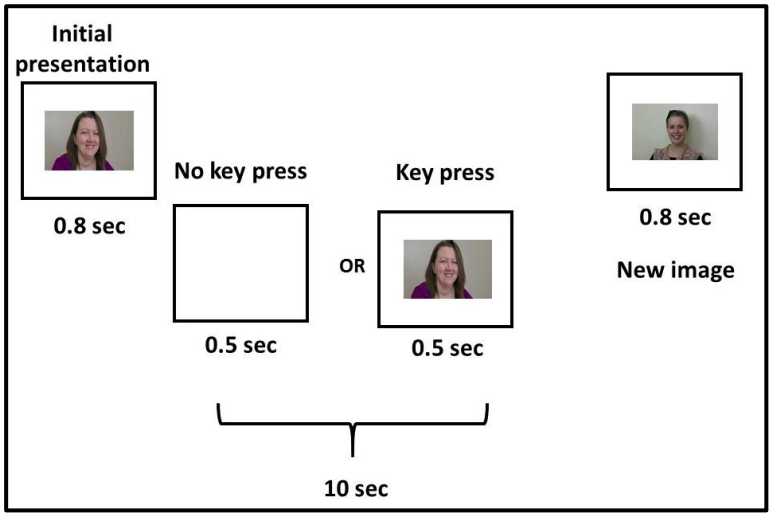

Figure 1.2 Illustration taken from Hayden et al (2007) to show the key press paradigm used to measure value of attractive faces in social decision making.

A different behavioural paradigm used to measure social seeking involves a forced choice between two stimuli and measures social seeking as preference of one stimulus over other. Deaner, Khera, and Platt (2005) used this paradigm with monkeys to measure the value of social status that might influence their decision making about social interactions. In this paradigm monkeys were presented with two targets to choose from (see figures 1.3.a and 1.3.b). One target always resulted in a fixed amount of juice and other resulted in variable amounts of juice along with the presentation of an image. The image of faces of a low status monkey, faces of a high status monkey, and female perinea were

used in different blocks. It was found that monkeys will accept variable amounts of juice to look at a female perinea and faces of a high status money.

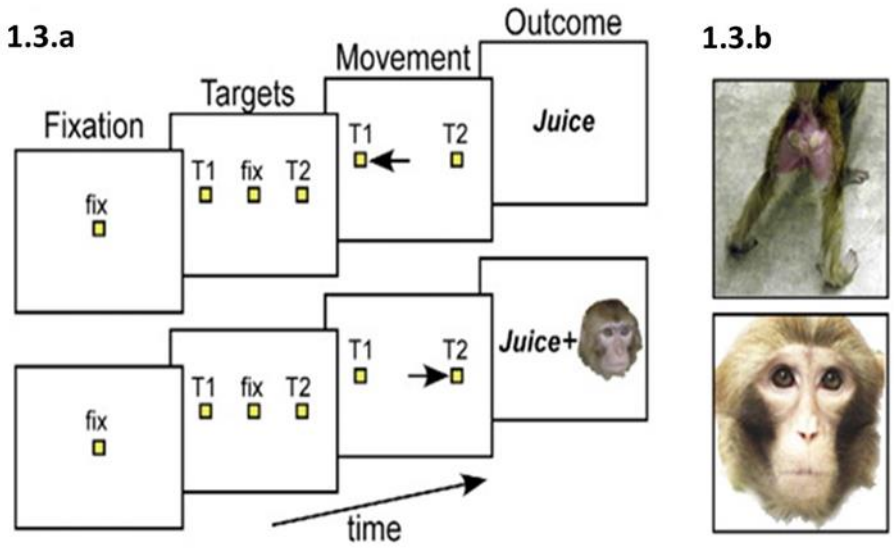

Figure 1.3.a) Paradigm used by Deaner et al (2005) for the valuation of images by monkeys. The monkey could choose between the two options by fixating on one of them **1.3.b)** example of images used. Figure is taken from Deaner et al (2005).

This paradigm provides the quantifiable value that a person would give-up to get a chance to see a specific stimulus. The task has now also been adapted to measure the value of social and non-social stimuli in humans (Watson et al., 2015), which will be discussed later in section 1.4.3.3.

An alternative paradigm based on a similar forced choice method, measuring the value of stimuli to estimate social seeking has been used by Shore & Heerey (2011). In this method participants are presented with a simple

'penny matching' game that they can choose to play against either a computer opponent or a person (see figure 1.4).

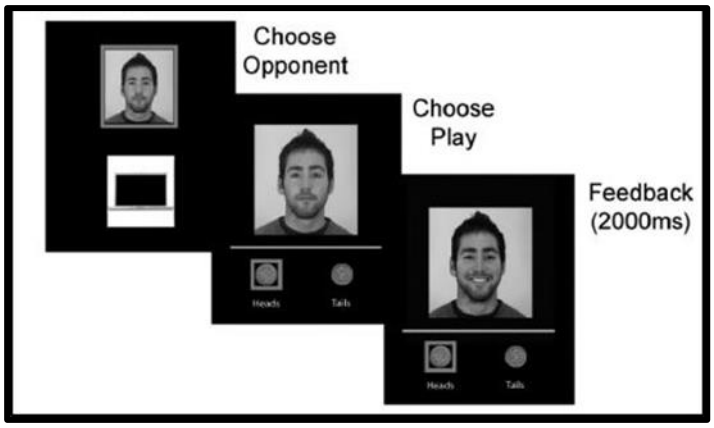

Figure 1.4 Penny matching game paradigm used to measure value of social vs non-social interaction in typical adults (figure taken from Shore & Heerey, 2011)

The chances of winning the money in the social condition were manipulated to vary from 85% to 40% of the time. The task thus evaluates the extent to which participants prefer to play against a social opponent in comparison to a non-social opponent. The choice of playing against a person despite having a lower reward frequency than playing against a computer opponent indicates a higher incentive value for social stimuli.

This section discussed several methods that have been used to date to measure social seeking in humans. They all try to understand social seeking as the behavioural effort made for a stimulus or the value attached to it. However, it is not yet clear if these measures are reliable and can be used with a wide

age range and clinical groups. In the next section I will discuss research which has employed these methods and will analyse if they are suitable measures of social seeking in different populations.

1.4.3.2 Social seeking in typical population: The concept of social seeking or lack of it and the need to evaluate it, have primarily emerged from observations of clinical populations such as ASD. Therefore there are very few studies that measure social seeking in only typical population. Shore and Heerey (2011) used a 'penny matching' computer game (discussed in the previous section, figure 1.4) with typical adults, and showed that people prefer to interact with a social opponent more than a non-social one. These participants gave up their chance to win more money in preference of having a social interaction over non-social.

More recently two studies have been conducted to explore social seeking in typical adults using a combination of behavioural and more direct brain measures such as Electroencephalogram (EEG). One of these studies by Cox et al. (2015) used social incentive delay task (SID) with Event Related Potential (ERP) in 35 typical adults. ERP measures electrophysiological changes in different brain regions in response to specific stimuli. Unlike the previous findings that strongly claimed higher reward value of social stimuli in typical adults, this study found that the reaction time, which is seen as a measure of 'seeking' in this paradigm, was fastest for the non-social incentive. However, in the same study, analysis of EEG data in relation to the autistic traits of the participants found that higher autistic traits are associated with attenuated P3 response in anticipation of social stimuli. This suggests lower social reward responsiveness in relation to the broad phenotype of ASD.

Another recent study by Flores, Münte, and Doñamayor (2015) compared EEG activation for the anticipation and viewing phases of the Social Incentive Delay task (SID) and Monetary Incentive Delay task (MID) including non-reward trials in 23 healthy adults. The results showed that participants' reaction times were faster for trials in which they were rewarded than non-rewarded, and the reaction time was particularly faster if it involved a social (as opposed to monetary) incentive. The EEG findings demonstrated that amplitude for N1 was larger for social incentives indicating more emotional involvement, and P3 was larger for monetary incentive condition indicating higher motivational value. These findings suggest that healthy developing adults may place high affective value on social interactions, though they also find monetary rewards highly motivating.

Overall these findings suggest that typical people may have a higher reward value for social stimuli that can influence their behaviour by either activating higher effort or by causing them to give up other pleasurable rewards like money. In the next section I will discuss the findings from studies that compare people with and without ASD, to examine if they have a different reward value for social stimuli.

1.4.3.3. Social seeking in ASD population: There have been several studies that have explored social seeking in ASD using a range of techniques. Chevallier, Grèzes, Molesworth, Berthoz, and Happé (2012) used a self-report questionnaire called 'The pleasure scale' (Kazdin, 1989) to measure social, physical and other sources of pleasures responses in high functioning people with ASD. They found that people with ASD report less pleasure for social

situations but not for non-social situations such as eating or spinning. Thus indicating that they may lack social liking which is an important element of social seeking. Another study using self-report measure on 68 adults with ASD suggested that people with ASD experience less pleasure in maintaining friendships (Baron-Cohen & Wheelwright, 2003). These studies indicate that people with ASD may have lower reward value for social interaction. However, it must be noted that both these studies only included ASD individuals with average intellectual functioning which represents only a small subgroup within this diagnostic category. As 70% of people with ASD show some level of intellectual difficulties (Feero, Guttmacher, Mefford, Batshaw, & Hoffman, 2012; Srivastava & Schwartz, 2014), we cannot be certain if these findings would generalise to the broader ASD population. Since self-report questionnaires are not an ideal measure for autistic individuals with learning difficulties due to demand on language comprehension and insight, other measures need to be used. Behavioural observations have always been a good method of obtaining information about an individual's behaviour and also have good ecological validity. Hauck, Fein, Waterhouse, and Feinstein (1995) conducted an observation based study with 18 children with ASD and 13 matched controls with learning disability. These children were observed for their social initiation behaviour over 15 minute sessions for 4 days in a classroom setup. It was found that ASD children initiated social contact with peers significantly less frequently than the learning disabled children, but they did not differ in the frequency of initiating social contact with adults. Also the nature of social initiation differed in quality between two groups. While children with learning disability made more spontaneous interactions and imitated teachers, children with ASD showed more ritualistic interactions such as social greetings.

Though behavioural observation methods can provide a good insight into the natural behaviour of people, it provides little control over the extraneous variables that can have major influence on the behaviour. For example in a class room observation it is difficult to control when, and how other people will interact with the child under investigation. Other factors such as light, noise, change in the school schedule and, teacher's behaviour cannot be control even when they can be the major determinant of a child's behaviour on a particular day. Therefore experimental methods are used more frequently than observation methods to understand the social behaviour of people with ASD. These methods are used alone, with self-report measure, and also with neurophysiological measures of brain activation for social motivation. In the next section I will first discuss the studies that used behavioural techniques either alone or with some self-report measures and then I will discuss the studies that used behavioural techniques with neurophysiological measures.

Social seeking has been evaluated in more controlled lab settings using eye-tracking methods by Chevallier et al (2015) to explore difference in duration of visual fixations on social and non-social stimuli in children with and without ASD. They used three sets of stimuli 1) an array of static social and non-social images (faces, vehicles, trains, cubes etc.), 2) video clips showing social and non-social stimuli, 3) video clips of a natural social interaction between two children (higher ecological validity). They found that children with and without ASD only differed in their total duration of visual fixation on the more naturalistic stimuli of social interactions. The other two sets of stimuli could not differentiate participants for their group membership. These findings not only support that social seeking might differ in children with and without ASD but also raises

concern over the validity of stimuli used in many laboratory based experiments discussed in the next section.

The other method regularly used to measure social seeking is the approach-avoidance techniques (as discussed in section 1.4.3.1) in people with ASD. Ewing et al. (2013) tested adolescent participants with ASD and matched controls, who were presented images of people and cars on a computer. The participants could increase the duration of looking at these images by pressing buttons on a keyboard. The results showed that both the groups made more effort to look at the cars than social images. There was no difference in the effort these two groups made to look at social images. In a different study Silva, Da Fonseca, Esteves, and Deruelle (2015) used a similar approach-avoidance technique to evaluate social motivation in adolescents with and without ASD. On each trial participants were presented images of real people and cartoons and they were expected to either pull (approach) or push (avoid) the joystick. Results showed that adolescents with ASD approached positive cartoon images and avoided real social images more than the matched group. Furthermore, these groups did not differ on their rating for affective valance and arousal for the images used in the study. These results suggest that though people with ASD can identify the emotional valance of images and express same level of arousal on an explicit rating measure, behaviourally they differ from the typical people. They actively avoid realistic social images, which supports the reduced social motivation theory of autism.

Deckers et al. (2014) used a slightly modified version of approach – avoidance task to measure social seeking in ASD. They evaluated 63 children with ASD on the “Wish for Social Interaction Scale” (WSIS) in which children were presented with pictures of other children and were explicitly asked if they

would like to play with them. The participants were also evaluated on a face-turn approach-avoidance task. This involved presenting pictures of people (social) and landscapes (non-social) on a computer screen, which the participants could manipulate using a joystick to orient the images to be facing towards or away from themselves. The participants were given instructions of turning the image in the direction given on each trial (e.g. left or right) and the reaction time of the participants' response was recorded. It was found that on WSIS children with ASD showed a reduced desire to have social interactions than typical controls. However, on the approach-avoidance task they had significantly faster reaction time for approaching (turning pictures towards themselves) both social and non-social images more than matched control group. Like Silva et al (2015) here again the findings from the explicit measure and the behavioural measure do not agree. Though on the explicit measure people with ASD show reduced social motivation on the behavioural measure they approach both social and non-social stimuli (Deckers et al., 2014).

Different from approach-avoidance methods Watson et al. (2015) used a choice task based on the work of Deaner et al (2005) (discussed in the section 1.4.3.1., figure 1.3), to evaluate reward value of social, non-social (low autism interest) and non-social (high autism interest objects such as trains and electronics) stimuli. They tested 12 children with ASD and 22 matched controls on three blocks. In each of these blocks participants were presented with a choice between images (from one category i.e. social, non-social high autism interest and non-social low interest object) and variable monetary reward against a scrambles images and fixed monetary reward. Participants could maximise their monetary gain by choosing the scrambles image and fixed monetary reward rather than going for category images and variable monetary

reward. The findings from this task showed that children with ASD preferred the options with variable chances of winning money and presentation of high autism interest non-social images, over the choice of consistent monetary reward and scrambled images. Hence the results suggest that people with ASD have high reward value for autism restricted interest images, but they did not differ from matched control in the reward value for social or low autism interest non-social images. These results do not directly support the theory of reduced social motivation but indicate that people with ASD have higher reward value of some specific non-social stimuli, which might interfere with their social development.

Another task to measure social seeking in ASD is the Social incentive delay task (SID). Delmonte et al. (2012) used SID with 21 ASD participants and matched controls while their brain activation was recorded using fMRI. The results showed that people with ASD showed reduced dorsal striatum activation, a brain area known to have influence on decision making by integrating influence of motivation and emotions, in response to anticipation of social reward. However, they were not different from matched controls for brain activation in response to anticipation for the monetary rewards. Furthermore, the ASD group had significantly lower reward system activation for social than non-social stimuli. Kohls et al (2011) used a variant of SID task. The only difference in this task is that unlike the original SID task, the cue in the beginning of the trials here does not indicate the strength of the reward but it indicates whether the participant should press or not the key. Kohls et al tested two groups of 18 adults with and without ASD. They reported that the people with ASD show generalised reduced brain activation for both monetary and social rewards.

The approach-avoidance paradigm too has been used with measures of physiological arousal to explore social seeking in ASD by Kylliäinen et al. (2012). In this study 14 participants with ASD and 15 matched controls were presented with images of familiar or unfamiliar adults with closed, open and wide open eye conditions. The findings showed that children with ASD have attenuated skin conductance responses compared to controls, to different eye-open conditions (gradually increasing from closed to open to wide-open eye conditions). Also typical children had higher left-sided frontal EEG activity, which is associated with approach motivation, in response to open eye condition compared to closed or wide eyes. No such difference in left-sided frontal EEG activity was observed for either of the eye open conditions in the ASD group (Kylliäinen et al., 2012).

On the whole, the studies using range of techniques to measure social seeking in ASD do not present a consistent argument in support of reduced social motivation theory. The findings are particularly mixed for the behavioural experiments. Perhaps the social preference expressed on questionnaires, recorded on the behavioural task, and observed in neuroimaging findings might be greatly influenced by the technique and stimuli used for its evaluation. In the next section I will discuss the limitations of these paradigms and other factors that might be responsible for inconsistent findings in ASD.

1.5 Rationale for the present research

In this section I will critically evaluate the tools used to date to measure social seeking, and will highlight the limitations imposed by them in

understanding social seeking in ASD. Commonly used social incentive delay (SID) task, assumes that the motivation to seek social contacts can be measured as anticipation. However, approach or seeking is a complex series of psychological events. It involves 1) the learning that the specific action results in acquiring incentive stimuli, 2) awareness of the positive consequences of the action, 3) motor or cognitive readiness to take action and the perception of the current situation that determine the action activation (Bindra, 1974). In the SID task participant is aware of the reward that will follow but has little control over the presentation/intensity of the reward. He/she primarily acts on the task about pressing the key as soon as the target is presented and is a passive recipient of the reward feedback at the end. SID can be seen as good task to measure the anticipation based estimate of social seeking response, but due to the above mentioned limitations (no control over type and strength of reward) it might not be the best measure of behavioural effort made by the participant to acquire the reward.

The approach –avoidance paradigms used in some of the previous research generally present one stimulus at a time and measure the participants' amount of effort to look at or avoid that stimulus. Though these kinds of paradigms do measure effort rather than a passive anticipation like SID, they do not present ecologically valid scenario. In most of the real life situations people have multiple options to choose from, and the choice of stimuli is influenced by the other available options. As suggested by Zellner, Allen, Henley, and Parker, (2006) the presence of a highly preferred stimulus lowers the reward value of another stimulus which was not preferred in the first place. This was demonstrated in an experiment by Zellner et al, in which it was found that people who drank full strength juice initially rated the diluted juice less

pleasurable than those who did not have the full strength juice before. Therefore the absolute reward value of a stimulus might be different from its relative value which is generally the case in real life scenarios. Neither approach – avoidance tasks nor SID task presents the participant the choice between two or more stimuli, hence making them different from most of the real life situations.

Most of the paradigms discussed in the previous sections i.e. approach-avoidance tasks (Deckers et al., 2014; Silva et al., 2015), choice task (Watson et al., 2015), and SID task (Delmonte et al., 2012; Spreckelmeyer et al., 2009), use the static images of social vs non-social stimuli. However, it is known that static stimuli lack ecological validity and might not be sensitive tool to elicit real life responses (Chevallier et al., 2015). A comparison between stimuli with different levels of ecological validity such as static images, acted and posed social interactions and natural social interaction video clips showed that the atypicality of visual attention in ASD becomes more prominent as the ecological validity of the stimuli increases (Hanley, McPhillips, Mulhern, & Riby, 2013). Therefore the tools used in the above experimental studies might not be reflecting the true nature of social seeking in ASD.

The approach-avoidance paradigms generally measure the behavioural responses of participants in terms of duration of viewing the target stimuli. The responses elicited by looking at a stimuli might be influenced by the reflexive action influenced by the low-level features of the stimuli than the learnt awareness of its pleasant properties (de Bordes, Cox, Hasselman, & Cillessen, 2013; Itier, Villate, & Ryan, 2007). Therefore, the behavioural response obtained on it can be highly specific to the set of stimuli used in the experiment rather than social or non-social category. This hence limits the generalisation of

the findings from this paradigm to the real life approach and avoidance behaviour.

Other than the above mentioned limitations, all the paradigms used here, especially the SID task requires the participants to have good cognitive abilities so they can understand the instructions of the task, which limits their use with wider population. Furthermore, SID task and approach-avoidance tasks generally use reaction time as a measure of social seeking. It is shown that people with autism have slower reaction time than typically control participants (Schunke et al., 2015; Todd, Mills, Wilson, Plumb, & Mon-Williams, 2009) therefore these tools might not be using the suitable behavioural measure for the ASD group.

Seeing the limitations in the above discussed paradigms used to measure social seeking it appears that there is strong need to have a behavioural paradigm that 1) measures social seeking objectively by sticking closely to the concept of motivation i.e. as a function of awareness of positive previous experience and behavioural effort; 2) uses ecologically valid stimuli; 3) controls for the effect of low-level features of the stimuli; 4) is easy to be used with people with different levels of cognitive ability and is not influenced by their language ability. The current research aims to develop a method that meets these criteria of measuring social seeking and can provide insight into social seeking motivation in ASD.

The research work undertaken during this doctoral thesis is presented in the chapters exploring the following objectives:

1. Development of the ecologically valid stimuli and development of the paradigm that can overcome the above cited limitations. Validating the

newly developed paradigm on typical adult population to measure social seeking.

2. Using the paradigm with adults with ASD to measure social seeking behaviour and test the theory of reduced social motivation in ASD.
3. Using the paradigm with younger participants with ASD to measure social seeking behaviour difference in ASD and typical adolescents.
4. Use of the paradigm with typically developing people between ages 4-20 years to explore the developmental trajectory of social seeking behaviour.
5. Comparison of the traditionally used approach- avoidance method with the newly developed method of measuring social seeking behaviour
6. The general discussion of the findings and future directions.

CHAPTER 2: DEVELOPING AND TESTING A NOVEL PARADIGM TO MEASURE SOCIAL SEEKING IN TYPICAL ADULTS

2.1 Introduction

In the last chapter I discussed the need to develop an objective measure of social motivation. I critically evaluated the behavioural measures used in the previous studies and highlighted the conceptual or practical limitations of these paradigms. Some of those limitations were 1) poor adherence to the concept of motivation, 2) limited ecological validity of the stimuli used in the paradigms, 3) limited control over the influence of low level visual features of the stimuli, and 4) use of language or complex instructions making the task suitable for a limited population only. Two major aims of this chapter are to develop a new paradigm that can overcome the limitations of previous methods of measuring social seeking, and to test the validity of this paradigm with typical adults. Hence this chapter is divided in two subsections, each focusing on one of these aims. These subsections are:

2.2 *Development of the paradigm*: In this section I will discuss how I conceptualise 'social seeking' for this thesis. I then move on to discuss the strategies I used to overcome the above discussed limitations of previous methods while developing a new paradigm to measure social seeking.

2.3 Testing the paradigm with typical adults: In the later part of the chapter I will present the first experiment conducted on typical adults to explore utility of the new Choose a Movie (CAM) paradigm to measure social seeking.

2.2 Development of the Paradigm

2.2.1 The concept of motivation and its extension to social motivation

"Social motivation" is a large umbrella term that denotes several behaviours that can easily be confused with proximal behaviours, for example 'an act of making a higher monetary donation to maintain reputation might easily be confused with a self-satisfying prosocial behaviour'. Therefore it is very important to have a clear and objective definition of the concept before it is measured. Recently Chevallier, Kohls, et al (2012) described social motivation as "*a set of psychological dispositions and biological mechanisms biasing the individual to preferentially orient to the social world (social orienting), to seek and take pleasure in social interactions (social reward), and to work to foster and maintain social bonds (social maintaining).* Here the aim of this thesis is to explore only a sub-concept of social motivation "social reward", which is also known as "social seeking". Social seeking as described in chapter one is the behavioural effort to get a stimulus that has previously provided pleasurable experience. To understand and define social seeking more clearly and objectively, I will first explore the definition of 'motivation' which has been

subjected to numerous investigations over time and then I will try to extend the knowledge gained from it to define social seeking.

Motivation has been defined in various ways, including: A drive to reduce the negative or increase the positive outcome by acting on the environment (Hill, 1963), a biological mechanism to maintain the homeostasis (Hull, 1943) or as an adjustment of opponent processes (Solomon, 1980). Berridge (2004) presented a comprehensive Bolles–Bindra–Toates theory of incentive motivation to understand motivation in behavioural neurosciences. As the name suggests this theory is based on the combined effort of Bolles–Bindra–Toates to understand motivation. Bolles (1972) describes the first aspect of incentive motivation as the establishment of Pavlovian association between the source of original pleasure and its cues. For example the regular presentation of a stimulus is linked with the ringing of bell on multiple occasions. The second aspect, as suggested by Bindra (1978) is the awareness of the association elicits behavioural readiness or action depending on the affective properties of the stimuli. In this instance a cue for food might initiate approach behaviour and a cue for shock might initiate avoidance reaction. Finally the third aspect, as suggested by Toates (1986) adds the element of subjective state of the organism in this process. Incentive value of the stimuli is influenced by the current state of the organism. For example, some stimuli might be more motivating for a person when he is experiencing a state of deficit than when he is not. Berridge (2004) further splits the incentive motivation into liking motivation and wanting motivation. He proposes that liking can be seen as the conditioned sensory pleasures associated with a stimuli whereas wanting is the incentive salience or the reward value one assigns to the stimuli at any moment (Berridge & Robinson, 1998).

Keeping Berridge's (2004) definition of incentive motivation in mind for this research project I describe social seeking to have three essential elements: 1) learnt association between cue and the social stimuli, 2) awareness of the reward properties of the expected social stimuli, 3) behavioural effort taken to approach the social stimuli. Based on the literature here I expect that the extent of effort made would indicate the extent of motivation for the stimuli. Therefore the paradigm developed for measuring social motivation in this research, closely adheres to Berridge's (2004) definition of incentive motivation.

Having established an objective definition to test the new paradigm against, I will now discuss the measures taken to overcome some of the limitations of the previous methods used to measure social seeking.

2.2.2 Stimuli generation

Researchers have always struggled to bring balance between the controlled experimental condition and ecological validity of the stimuli used to evaluate social motivation. Studies have used variety of stimuli to get genuine social responses from their participants. Most of these studies used static images of human faces and comparable non-social stimuli like cars, trains, household objects (Deckers et al., 2014; Delmonte et al., 2012; Ewing, Pellicano, & Rhodes, 2013; Sasson, Turner-Brown, Holtzclaw, Lam, & Bodfish, 2008; Watson et al., 2015). Cassidy, Mitchell, Chapman, and Ropar (2015) used both static (still images) and dynamic (video clips) stimuli to measure emotion processing in ASD and found that dynamic stimuli are more informative and can help people understanding complex emotions than the static stimuli. Therefore other research exploring social processing in ASD have used videos of people to present as social stimuli. These video clips with rich social content

are taken from films, TV programs, and cartoons (Klin et al., 2002; Nakano et al., 2010; Riby & Hancock, 2009). However, the above mentioned studies (Cassidy et al., 2015; Klin et al., 2002; Nakano et al., 2010; Riby & Hancock, 2009) focus on the social orientation or other factors influencing social difficulties in ASD rather than social seeking. Even after evidence of higher efficacy video stimuli over static images in eliciting the complex behavioural responses in ASD, most of the studies evaluating social seeking use the static images rather than video stimuli.

The most ecologically valid stimuli i.e. the real-life stimuli/situation are primarily used in the studies exploring maintenance component of social motivation. Such as study evaluating "collaboration" in chimpanzees and typical children used real life problem (Rekers et al., 2011), "flattery" in typically developing children (Fu & Lee, 2007; Talwar et al., 2007), or mimicry in adults (Chartrand & Bargh, 1999; Lakin & Chartrand, 2003). Like video stimuli, real life stimuli too have not been used to measure social seeking component of social motivation.

As there has been a debate about the ecological validity of video vs real life stimuli. Freeth, Foulsham, & Kingstone (2013) used both of these i.e. video as well as live interaction to evaluate the social orientation in relation to autistic traits. They found that the two methods had significantly different effects on the findings. Participants spent significantly longer time looking at the background when stimulus was presented in video than in the live interaction. At the same time author emphasised the poor control over extraneous variables to be a major limitation in live condition stimuli than video.

Overall, it is clear that the lab based stimuli provide better control over the extraneous variables but lack in ecological validity, whereas, real life

observations have good ecological validity but poor control over variables. However, although there are several advantages in using dynamic social stimuli, the literature about social seeking has primarily been limited to the use of static images. To maintain a suitable balance between experimental control and validity of the stimuli I decided to use the video stimuli in the paradigm. Three sets of stimuli - social direct gaze, social averted gaze, and non-social (see figures 2.1, 2.3, and 2.4) were developed for the paradigm. For the social stimuli equal numbers of male and female adults were video recorded while they responded with a smile to a friend or partner. The social smiles for the stimuli were recorded using two cameras to capture it from straight as well as averted angles as shown in figure 2.1.The positive social expression was chosen for the social stimuli as it is suggested that smile from potential social partner, results in anticipation of positive interactions (Kringelbach & Rolls, 2003). As the definition of social seeking suggests the positive experience result in higher efforts to experience social interactions in future, it is expected that smiling social stimuli might motivate participants to seek them more.

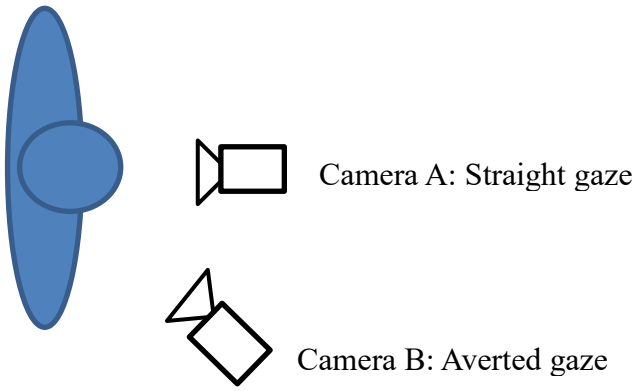

Figure 2.1: Schematic example of video recording of the social stimuli.

As Shore and Heerey (2011) argued that genuine smiles have a higher social reward value than polite smiles, we developed social stimuli with genuine smiles. To elicit a genuine social smile we followed a procedure based on Stanislavski's (1975, as cited in Gosselin, Kirouac, & Doré, 1995) technique of emotional memory. In this technique actors were asked to imagine that he/she is sitting in a café reading a book, when a close friend calls him/her from different directions. To facilitate the imagination a close friend of the model called him/her in reality as well. Several such smile responses of each model were video recorded and at the end the best two straight gaze smiles and their corresponding averted gaze smiles were selected for the next step.

The selected social smile videos were than rated by 16 undergraduate students on five positive social dimensions: Genuineness, friendliness, naturalness, attractiveness, and likableness. These dimensions were selected for having higher positive social value. The smile videos were presented on a computer screen with the question at the top asking about any one of the five dimensions (see figure 2.2). The participant then rated the video on a Likert scale of 1-5 by pressing a number on the keyboard. Here "1" was "not at all"

and “5” was “absolutely”. As the aim was to create stimuli that can generate positive social experience to motivate social seeking only the positive social dimensions were chosen to rate the stimuli. The dimensions selected based on the evidence that genuine (Shore & Heerey, 2011) and attractive (Aharon et al., 2001) social stimuli are more rewarding than unnatural, or unattractive. One data set was deleted from analysis as the participant pressed multiple keys for each trial, finally leaving data from 15 participants.

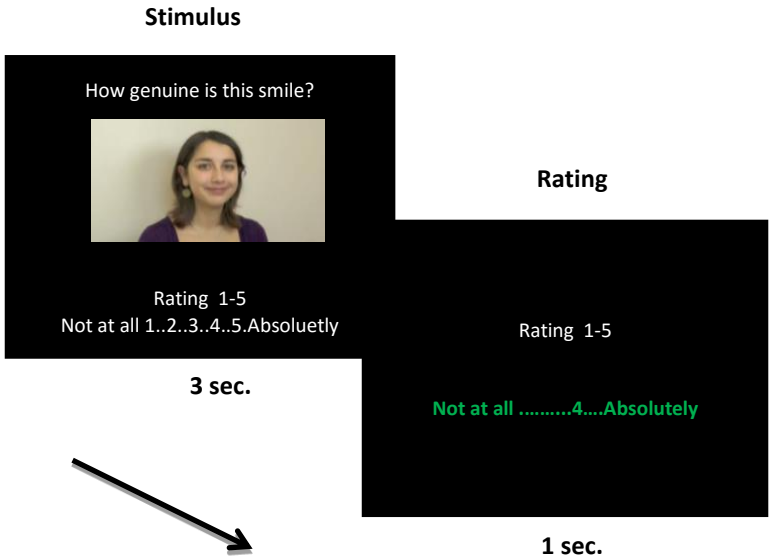

Figure 2.2: An example of the trials of the experiment conducted to select the best social stimuli

The ratings on all the five dimensions were highly correlated (*r = 0.65 to 0.93, p < 0.001* except for the correlation between genuineness and attractiveness *r = 0.54, p = 0.1191*) as shown in *table 2.1*. Therefore the average rating for all the dimensions for each smile was calculated to identify the smiles with the highest positive social value.

Table 2.1: Correlation coefficient table for ratings of all the videos on five social dimensions

	Genuine	**Attractive**	**Likeable**	**Friendly**
Genuine	--			
Attractive	$r = 0.54$, $p = 0.1191$	--		
Likeable	$r = 0.81$, $p < 0.0001$	$r = 0.75$, $p < 0.0001$	--	
Friendly	$r = 0.79$, $p < 0.0001$	$r = 0.69$, $p < 0.0001$	$r = 0.93$, $p < 0.0001$	--
Natural	$r = 0.89$, $p < 0.0001$	$r = 0.65$, $p = 0.0001$	$r = 0.85$, $p < 0.0001$	$r = 0.799$, $p < 0.0001$

It was also found that overall averted gaze videos were rated lower than direct gaze videos. Consequently any direct gaze video corresponding to a high rated averted gaze video was likely to have higher rating than vice-versa. Therefore, the 10 highest rated averted gaze videos (equal number of males and females) and their corresponding straight gaze videos were selected as social stimuli for the behavioural paradigm. This makes sure that the selected videos have the highest positive rating for both the categories.

For non-social stimuli, 10 pairs of common household objects such as bowl and jar, shampoo and loofah, paint and brush were video recorded while

slowly rotating on a table (schematic presentation shown in figure 2.3). The objects were recorded with movement to make them comparable to the social videos which also had movement.

Figure 2.3*:* Schematic example of video recording of the object stimuli.

Finally three sets of video clips: social direct gaze, social averted gaze, and non-social objects, each 3 seconds long were selected to be used in the paradigm. Some examples of these stimuli are presented below in figure 2.4.

Figure 2.4: Sample images from the three sets of movies. First column shows non-social stimuli, middle column shows direct gaze social stimuli, and last column shows the corresponding averted gaze social stimuli.

The two sets of social videos are highly matched as they are the same events recorded from two sides. In regards to the non-social stimuli, it is difficult to come to a consensus about what can be used as the most suitable stimuli that could be comparable to the social stimuli. To avoid any novelty effects it was decided to use regular household objects and avoid any object that might relate to a special interest of individuals with ASD like machines, vehicles, computers, and Lego (Baron-Cohen & Wheelwright, 1999). Due to limited matching between social and non-social stimuli I further needed to control the influence of low level features of these stimuli on the preference behaviour. The measures taken to do so are discussed in the next section.

2.2.3 Control over the influence of low level visual features of the stimuli

As discussed in the previous chapter (section 1.5) presentation of the stimuli at the time of making an approach / seeking related decision can introduce several uncontrolled factors such as novelty, colour, or brightness based differences between the stimuli type. One way to overcome these low-level differences would be to conduct a saliency analyses. However, this could be extremely difficult to ensure all 3 sets of stimuli matched across a variety of low-level features. Instead it was decided to design the paradigm in a way so that decision to view a particular type of stimulus was made prior to viewing it. This would mean low-level features would be less likely to influence the decision process. Therefore in the new paradigm three coloured patterns, that were similar in terms of brightness and complexity, were chosen from internet, and used as cues to the three sets of stimuli. The primary colours and patterns resembling recognisable shapes were avoided while choosing these patterns. The similarity in terms of brightness and complexity of the patterns was checked by visual evaluation of the boxes by the research team. As shown in the figure 2.5, for any participant the association between the patterned boxes and the sets of stimuli would remain same through the experiment. Therefore looking at these boxes would make them aware of the available stimuli. This did not only help in eliminating the influence of the low-level visual features of the stimuli, but also helped in meeting the first aspect of the definition of motivation (section 2.1) i.e. ‘learnt association between cue and the stimuli’.

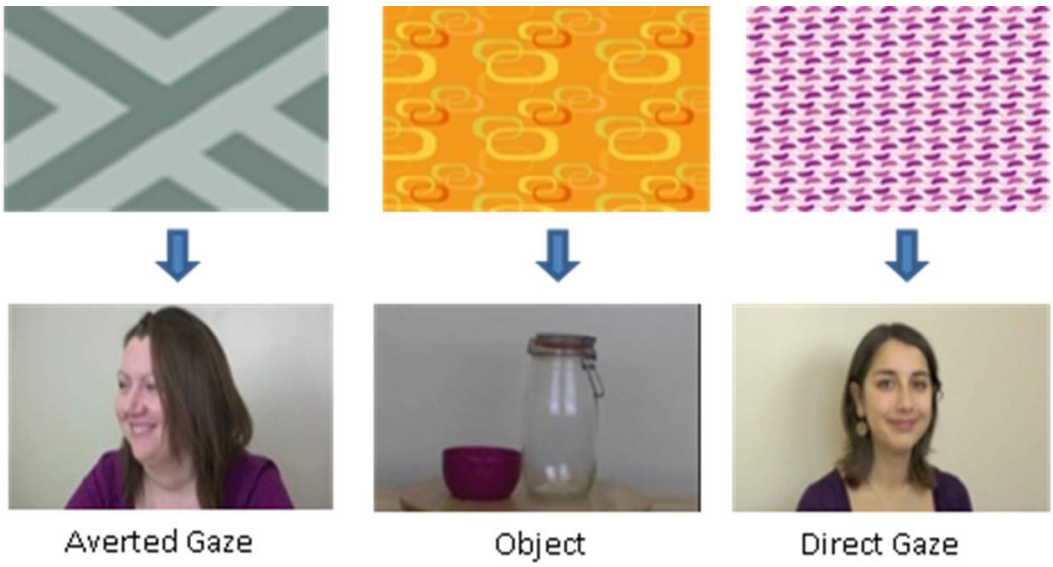

Figure 2.5*:* Sample of the patterned boxes used to link with the set of stimuli as cues.

To ensure the choices were not influenced by any specific features of the pattered boxes, the association between the boxes and the stimuli were counterbalanced between the participants. For example the green stripy box was linked to the averted gaze stimuli for one participant and linked to object for another participant (figure 2.5). The learning of this association would ensure that the participants expected to see a specific stimulus if they selected a particular box. Therefore the first set of trials of the paradigm aimed to establish that the participants learned this association.

As the basic building blocks for the new paradigm were established I now proceeded to formulate the overall structure of the paradigm. In the next section I will discuss the presentation of the stimuli and the trials structure of the paradigm including the steps added to ensure learning of the association between the patterned box cues and the stimuli.

2.2.4 Final Choose a Movie (CAM) paradigm

One of the major limitations of the previous paradigms was their limited utility for people with limited cognitive abilities and use of complex language based instructions. Therefore the aim of this research was to develop a paradigm that is simple to understand and can be explained using minimal language or visual signals only. A simple choice task appeared to be the best option for this. Therefore the final paradigm involved choosing between two boxes to view either a social or non-social movie. This paradigm is hence named the 'Choose a movie' (CAM) paradigm.

2.2.4.1 Associative learning trials of CAM paradigm: During the initial phase of the paradigm, participants were given very simple instructions to open the box on left by pressing key 'Z' and open the box on right by pressing key 'M'. In addition, the following instructions were presented on the screen "*You will see some boxes with locks. Open the locks to see a video. Press "Z" to open the locks at your left or Press "M" to open the locks at your right*". Participants then saw any one cue image of box either on left or right side of the screen. Each time they pressed the appropriate key the lock on the box animated to open and disappeared from the screen. Then the box extended to the full screen. This step was added to ensure that participant focused on the pattern before he/she looked at the movie. Finally, the movie played for the participant (figure 2.6). Participants saw 5 associative learning trials for each box, resulting in 15 associative learning trials in total. This phase of the paradigm could be run with minimal instruction or with very little support to the participant to identify the two keys for right and left boxes.

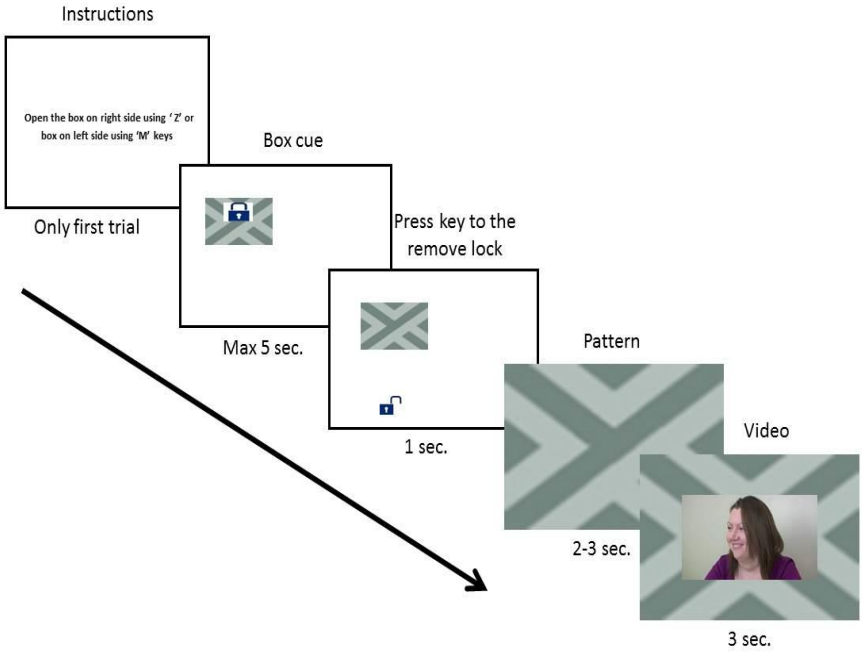

Figure 2.6*:* Associative learning trials in which participants learned that each box had only one kind of movies.

2.2.4.2 Practice and Experimental Choice trials of the CAM paradigm: After the initial associative learning trials, participants were informed that they would see two boxes on the screen. The following instructions were presented on the screen "*You will see some boxes with locks. Open the locks to see a video. You can choose freely which locks to open. Press "Z" to open the locks at your left or press "M" to open the locks at your right*". The participants then completed six practice trials during which they could ask if they had any questions. It was expected that after these practice and earlier associative learning trials participants would be familiar with the task and know how to remove the locks.

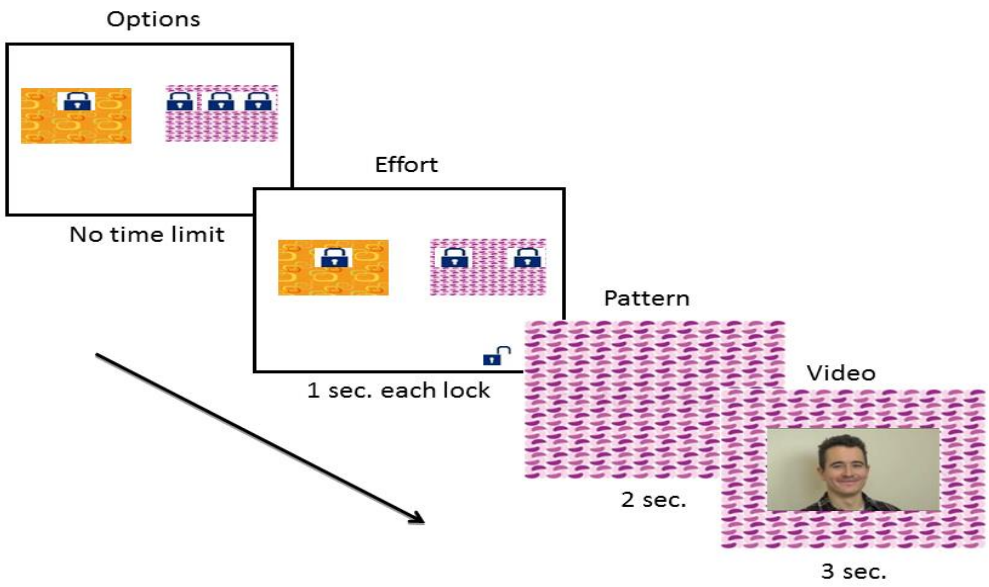

Figure 2.7*:* An experimental choice trial, in which a participant removed three locks to view a social movie (direct gaze).

The practice trials were then followed by the experimental choice trials in which participants saw one of three possible stimuli pairings: Direct gaze vs averted gaze, direct gaze vs object, averted gaze vs object stimuli. Finally, 180 trials, comprised of 60 trials with a choice between direct gaze and averted gaze; 60 direct gaze and object trials; and 60 averted gaze and object trials were presented. Within each set of 60 trials, 32 trials had 3 locks on one box and 1 on the other; 8 trials had 2 locks on one box with 1 on the other, 8 trials had 3 locks on one box with 2 on the other, and 12 trials had equal numbers of locks on each box. The boxes with the larger number of locks were pseudorandomly assigned to the left or right side of the screen with equal probability for each number of locks.

On each trial, a participant could choose to open the box with fewer locks (fewer key presses and quicker) or the box with more locks (more key presses and slower). Thus, participants were encouraged to make a trade-off between the effort required to open the box and their preference for a particular stimuli category. The effort made to open any box was taken as a direct measure of the value a particular stimuli holds for an individual.

The task instructions were simple and only required minimal language understanding. The consistent contingency between key presses and opening of the corresponding box is a very simple association hence the task was accessible to people with limited cognitive ability or young age. The next step after the development of the paradigm was to test it with typical adults to evaluate its efficacy in measuring social seeking. Previous research has shown that typical adults prefer to have social over non-social interactions (Shore & Heerey, 2011), to be a useful measure of social seeking it was expected that the new paradigm would be able to demonstrate similar social preference in typical adults. With this aim the first experiment using the CAM paradigm was designed. The next section of the chapter presents this experiment evaluating efficacy of the paradigm with typical adults

2.3 Testing the Choose-A-Movie (CAM) paradigm with typical adults

2.3.1 Introduction

Motivation to seek a stimulus can be quantified in terms of the utility or the reward value (an estimate about the expected positive outcome from the choice) of that stimulus (Lin, Adolphs, & Rangel, 2012). Any stimulus with higher reward value is more likely to activate approach behaviour. For example, food with higher rewarding value is approached more than the food with low rewarding value (Epstein et al., 2004). Similar results have been found for social stimuli. People place higher value on genuine social smiles then polite smiles, hence they even give away some monetary rewards to see genuine smiles (Shore & Heerey, 2011). Another study showed that typical heterosexual males exert more effort to watch the images of attractive females than average looking females (Hayden et al., 2007). Gaze is one social cue which seems to be particularly rewarding. Seeing an attractive face making direct eye contact engages brain systems linked to reward (Kampe, Frith, Dolan, & Frith, 2001), and infants fixate longer on stimuli with straight eye gaze compared to averted gaze (Farroni, Csibra, Simion, & Johnson, 2002).

However social interactions do not have the same reward value for all people. One questionnaire based study using a large sample of 472 typical adults showed that higher autistic traits are associated with less enjoyment on social activities including social admiration (Foulkes, Bird, Gökçen, McCrory, & Viding, 2015). Furthermore these traits are also linked to reduced pleasure in sexual as well as prosocial activities. The results from the same study also suggested that people with higher autistic traits may have poor reward value for social stimuli. Another study exploring the relationship between reward learning,

prosocial behaviour and autistic traits suggested that people with high autistic traits are not influenced by the previously rewarding social interactions while making decision about current prosocial behaviour (Panasiti, Puzzo, & Chakrabarti, 2015). Panasiti et al argued that though high autistic traits do not disrupt the ability to learn the association between positive or negative experience with social interactions but these experiences may not translate in socially desirable behaviours.

Cox et al. (2015) explored the neural correlates of social motivation in relation to autistic traits. They used electro-physiological measure to explore P3 activation in relation to social and non-social rewards in typical adults. The P3 component indicates the activity of the Locus ceruleus-norepinephrine (LC-NE) system which suggests the reward salience of the stimuli. The results from this study suggested that higher autistic traits correlate with attenuated P3 response to anticipation of social but not non-social rewards (Cox et al., 2015). Similarly Sims, Neufeld, Johnstone, and Chakrabarti (2014) explored the relation between neural circuits for reward and the mirror system in relation to autistic traits. They suggested that low levels of social mimicry as observed in people with high autistic traits might be due to deficits in the social reward system than deficits in mirror system.

The aim of the present experiment was to explore if the Choose a Movie (CAM) paradigm would be a useful measure of the preferences between social (direct and averted gaze) and non-social stimuli in typical adults. This experiment also explored the role of autistic traits in influencing the choice between social and non-social stimuli in typical adults. On the basis of above literature it was hypothesised that typical adults would prefer to choose direct gaze social stimuli over averted gaze social stimuli, and would choose any

social stimulus over non-social. Based on the reduced social motivation theory of ASD it was hypothesised that participants with higher levels of autistic traits would show a weaker social preference.

2.3.2 Methods

2.3.2.1 Participants: Eighty adults (39 Females, age 18-43 years) participated in the experiment. Participants were recruited by posters in different science/business/arts departments of University of Nottingham. One participant reported having positive family history of ASD in a first degree relative. As we did not pre-define family history of ASD as a criterion for exclusion, he was included in the study.

2.3.2.2 Procedure: Ethical approval for this experiment was provided by the ethics committee of School of Psychology, University of Nottingham. Participants first gave written informed consent to take part in the experiment. They then completed the Adult Autism Spectrum Quotient (AQ) (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001). Two of the participants scored above the cut-off (32) on AQ for the general population (Baron-Cohen et al., 2001) but had never been assessed for or diagnosed with ASD, therefore they were included in the study. Next, the CAM paradigm was presented using MATLAB with Cogent toolbox. The details of the paradigm are given in the previous section 2.4.

2.3.2.3 Data analyses*:* Each participant's data from the 180 multi-lock experimental choice trials was split into three sets of 60 trials, one set for direct-gaze vs object choices; one for averted gaze vs object; one for direct gaze vs

averted gaze. Three separate models were fitted for the three separate choice pairs, so model 1 includes only trials where participants chose between direct gaze and objects; model 2 includes only trials where participants chose between averted gaze and objects; model 3 includes only trials where participants chose between direct and averted gaze. For each model, data from all participants was fitted simultaneously using a mixed-level generalised linear model in SPSS, i.e. data for all 80 participants for the direct-gaze vs averted gaze choice pair was entered into a mixed-level model. This expands on the approach of Shore and Heerey (2011). This model used the logistic link function

$$p\ (\text{left}) = e^t / (1 + e^t)$$

in which *p (left)* is the probability of selecting the box on left and *t* is the difference in the utility between the two boxes. Utility was modelled as a linear function of the effort required to open the box, the stimuli type and their interaction.

$$t = \beta_1 x_1 + \beta_2 x_2 + \beta_{3X3}$$

Here x_1 is the difference in the number of locks on the two boxes (-2 to 2), x_2 is a dummy variable coding the identity of the item in the left box (e.g. 1 = direct gaze; 0 = averted gaze), x_3 is the interaction between x_1 and x_2. In this model, participant's probability of choosing the item on the left was predicted using following factors: *Effort* - the relative number of locks on the left (-2, -1, 0, 1, 2), *Stimulus* - the identity of the stimulus on the left (e.g. direct gaze / averted gaze) and interaction of effort by stimulus. Other predictors were included as participant-level factors, namely the participant's AQ score, their age, and gender. Thus, a single mixed-level model was used to analyse all the data for each choice pair. The main effects of all predictors and also for interactions of effort by stimuli, effort by AQ, stimuli by AQ; and effort by stimuli by AQ were

evaluated. Data were analysed in SPSS and results are reported in terms of the Wald statistic.

2.3.3 Results

In this experiment 80 typical adults were tested using the Choose-a-Movie (CAM) paradigm to measure their social motivation and the Autism Quotient Scale-AQ (Baron-Cohen et al., 2001) to measure their autistic traits. Results (see also figure 2.8) showed choices in the direct-gaze vs object trials were reliably influenced by the stimulus category (Wald $\chi^2 = 17.40$, $p < .001$), effort (Wald $\chi^2 = 17.04$, $p = .002$) and autistic traits (Wald $\chi^2 = 3.88$, $p = .049$). Critically, there was a significant interaction between stimuli and AQ (Wald $\chi^2 = 6.03$, $p = .014$). No other interaction between these factors was significant. Also there was no significant effect of age or gender on the choice of the participants. For choices between averted gaze movies and objects, participants' choices were again significantly influenced by interaction between stimuli and AQ (Wald $\chi^2 = 8.99$, $p = .003$) (other effects were similar to before, see table 2.2). For choices between averted gaze movies and direct gaze movies, the interaction between stimuli and AQ was a marginal predictor of choice (Wald $\chi^2 = 3.51$, $p = .061$).

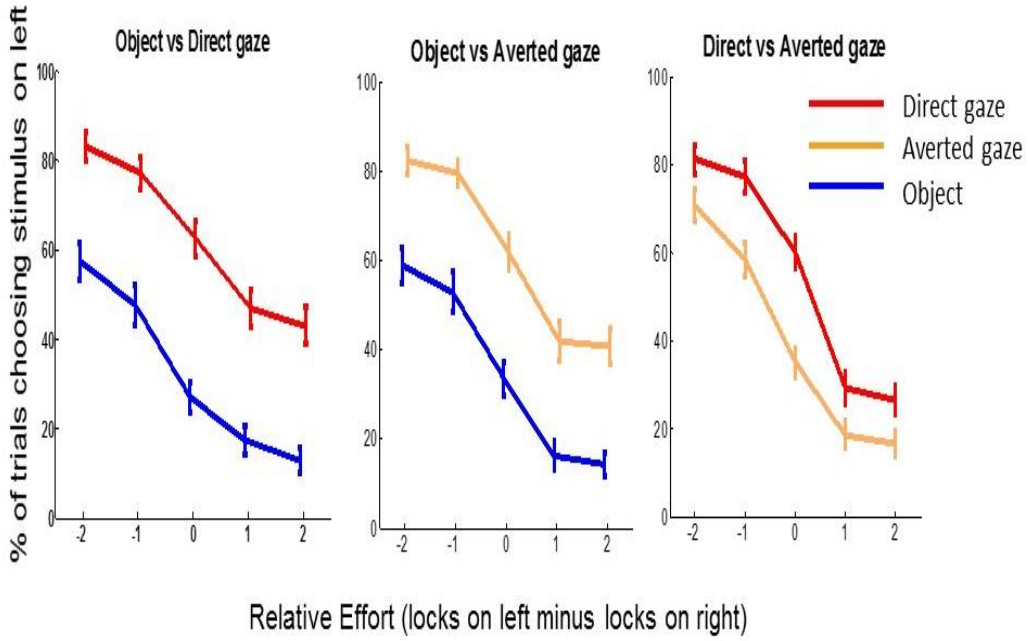

Figure 2.8: Choices according to effort and stimuli. Each plot shows how often (%) the participant chose the left box for a particular level of effort. The coloured lines indicate which stimulus category was in the left box on each trial. For example, in the left-hand plot the red line above the blue line indicates participants preferred direct gaze videos.

To further demonstrate the relation between the preference and autistic traits of participants, a regression analysis was done for stimuli type and the autistic traits (figure 2.9). The regression analysis suggested that autistic traits were significant predictors for the preference for non-social stimuli i.e. object in averted gaze vs object choice trials (p = 0.04), and marginally significant predictor for preference for object in direct gaze vs object choice trials (p = 0.055). However they were not a reliable predictor for choice for any one

stimulus in direct vs averted gaze choice trials where both choices were social in nature (p = 0.21).

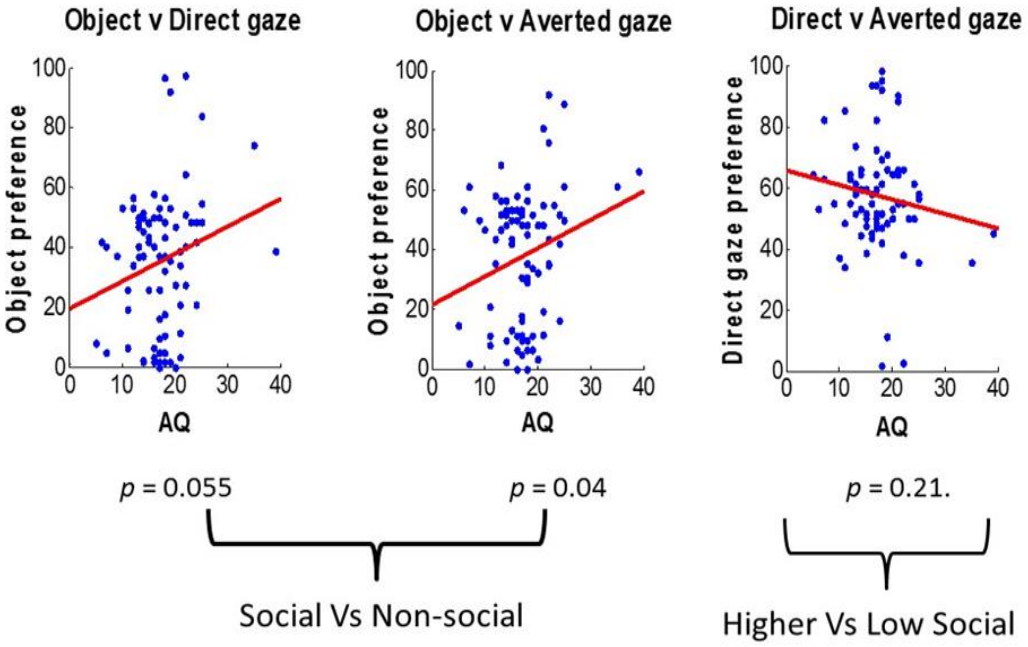

Figure 2.9: Relationship of preferences to autistic traits. Right: Object preference on direct gaze vs object trials was marginally related to autistic traits. Centre: Object preference on averted gaze vs object trials was significantly related to the autistic traits. Left: preference for direct gaze social stimuli on direct gaze vs averted gaze trials was not related to autistic traits.

Overall, these results showed that the typical adults preferred social (direct or averted gaze) movies over object movies and the extent of this preference was linked to their autistic traits. Participants with higher levels of autistic traits showed a weaker social preference, indicating that they attached

less value to social movies, however between two social stimuli participants' choice was marginally influenced by the gaze direction in the stimuli.

Table 2.2: Logistic regression: factors influencing participants' decision to choose stimuli on the left.

	Object vs direct gaze (Wald χ^2, *p*)	**Object vs averted gaze (Wald χ^2, *p*)**	**Direct vs averted gaze (Wald χ^2, *p*)**
Stimulus	17.41, $p < 0.0001$	20.02, $p < 0.0001$	9.72, $p = 0.002$
Effort	17.04, $p < 0.002$	20.51, $p < 0.0001$	18.60, $p = 0.001$
AQ	3.88, $p = 0.049$	0.628, $p = 0.428$	0.019, $p = 0.889$
Stimulus X AQ	6.03, $p = 0.014$	8.995, $p = 0.003$	3.51, $p = 0.061$
Stimulus X effort	3.41, $p = 0.492$	3.25, $p = 0.517$	2.45, $p = 0.654$
Effort X AQ	4.46, $p = 0.348$	7.61, $p = 0.107$	6.46, $p = 0.167$
Stimulus X effort X AQ	2.81, $p = 0.591$	4.50, $p = 0.343$	2.03, $p = 0.730$
Age	0.143, $p = 0.705$	0.581, $p = 0.446$	0.130, $p = 0.719$
Gender	0.510, $p = 0.475$	2.40, $p = 0.121$	1.35, $p = 0.246$

The overall preference (collapsed over the effort levels) for three sets of stimuli while they were presented with three different coloured boxes were also compared i.e. preference for direct gaze stimuli in direct gaze vs object trials when social stimuli was linked to green box, linked to orange box, and linked to pink box. Results showed that there was no significant difference in the preference for stimuli when linked to the three cue boxes direct gaze stimuli in direct gaze vs object ($F(29, 49) = 1.051$, $p=0.452$), averted gaze in averted gaze vs object ($F(29, 49) = 1.030$, $p=0.476$), and direct gaze in direct gaze vs averted gaze ($F(29, 49) = 1.241$, $p=0.267$).

2.3.4 Discussion

Using a novel behavioural Choose-a-Movie (CAM) paradigm, it was demonstrated that typical adults have a reliable preference for social stimuli, and that this preference is reduced in those with higher autistic traits. These data suggest that typical adults value direct gaze social stimuli more than averted gaze social stimuli or non-social object stimuli. In the next sections these results are discussed in terms of measuring social motivation using CAM in typical population in relation to their autistic traits.

The findings from this experiment suggest that the novel CAM paradigm provides a straightforward method to quantify social seeking motivation in typical participants. It differs from previous measures of social seeking in several ways. Shore and Heerey (2011) measured social seeking by presenting the stimuli (person vs computer) on the screen while participants made decision about their preferred opponent, but it is hard to determine if the results obtained using this kind of measure are driven by low-level stimulus features or the higher

reward value of any stimulus. In the present experiment, when the participant made a choice, they only saw abstract cues (boxes) on the screen and were guided by an internal value signal which was based on their learning of association between stimuli and cue and the reward value they ascribed to the stimulus.

In some of the previous studies researchers used neuroimaging measures to estimate the reward value of a stimulus (Delmonte et al., 2012; Kohls, Schulte-Rüther, et al., 2013; Scott-Van Zeeland, Dapretto, Ghahremani, Poldrack, & Bookheimer, 2010), however these methods are hard to apply across a wide range of participants. CAM paradigm on the other hand requires minimal language resources and due to very limited need for verbal instructions it can be used with a wide population including people with limited cognitive abilities.

Using the CAM paradigm, it is clear that typical adults value a smiling face with direct eye contact over a smiling face with averted gaze or objects, and value an averted gaze face over objects. Participants were prepared to put in more effort to see their preferred stimulus.

CAM paradigm was also used in this experiment to explore if there is any relation between autistic traits and social motivation (Chevallier, Kohls, et al., 2012). It allowed for the evaluation of the influence of stimuli, effort, and their interaction along with autistic traits on the choice behaviour of the participants. This paradigm clearly demonstrated a reliable relationship between AQ scores and the preference for a social stimuli over non-social i.e. objects. The results from the logistic regression analysis showed that autistic traits of the participants influenced their choice between social vs non-social stimuli. These results thus lend support to the claim that difference in social

motivation might underlie atypical social behaviour in ASD (Chevallier, Kohls, et al, 2012). These results are also coherent with the findings of Haffey, Press, O'Connell, & Chakrabarti, (2013). Haffey et al tested 36 participants on a mimicry task in which social and non-social cues were previously associated with high reward and low reward outcomes. They found that high autistic traits were negatively correlated with the mimicry of social *conditioned* cues but not the non-social *conditioned* cues. Here *conditioned* cues referred to the value of mimicry obtained by subtracting mimicry on low-reward condition from the mimicry of high-reward condition. Thus, both, the results from the current experiment and Haffey et al's suggest that people with high levels of autistic traits value social stimuli less than the non-social stimuli.

The finding that social direct gaze is valued less in participants with higher autistic traits is also compatible with a number of previous studies that measured social reward in ASD using face stimuli with direct gaze (Delmonte et al., 2012; Kohls, Schulte-Rüther, et al., 2013; Scott-Van Zeeland et al., 2010). Furthermore, a failure to make or respond to eye contact is a diagnostic indicator for ASD (American Psychiatric Association, 2013), and some studies suggest that direct eye contact might be hyper-arousing for children with ASD (Kylliäinen & Hietanen, 2006). However, the findings from this experiment do not fully support the hyper-arousal theory of social avoidance in ASD since the participants with higher autistic traits did not completely avoid looking at social stimuli. Instead, they preferred non-social stimuli more but if the effort associated with them was increased they switched to choose social stimuli. Nevertheless, it must be kept in mind that this experiment was done on typically developing adults; hence the results of it might not be generalizable to the ASD population.

2.3.5 Conclusions

In summary, these findings suggest that social motivation can be measured using a simple behavioural method, which controls for lower level visual features of the stimuli and gives a precise measure of social seeking. Furthermore, the autistic traits of typical adults predict their preference for social and non-social video stimuli. This means that the paradigm used in this experiment can serve as an effective measure of social seeking in ASD, which is perhaps a strong factor influencing their day to day social behaviours.

CHAPTER 3: SOCIAL MOTIVATION IN ADULTS WITH ASD

3.1 Abstract

Avoidance of gaze and social stimuli is commonly reported in autism spectrum disorders (ASD). A recent theory attributes this to a reduced motivation to engage with others, that is, deficit in social motivation. However, there are currently few simple, direct, behavioural ways to test this claim. This study uses the Choose-a-Movie (CAM) paradigm to test if preferences for social/non-social stimuli are linked to the diagnosis of ASD. CAM measures the effort participants make to view a particular set of stimuli. This aspect of social motivation is known as social seeking. In this study, 30 adults with ASD and 24 age/IQ matched typical adults completed the CAM paradigm. The results showed that adults with ASD have a significantly reduced preference for direct gaze social stimuli, but there was little difference in their preference for faces with averted gaze. These data show that social seeking motivation can be measured in adults with ASD using a simple behavioural paradigm. Furthermore, adults with ASD prefer direct gaze less than typical adults, but may not avoid faces with averted gaze. This data advances our understanding of how social motivation may differ between those with and without ASD.

3.2 Introduction

Autism spectrum disorders (ASD) is a neurodevelopmental condition characterised of significant difficulties in social-communications and presence of repetitive behaviours (American Psychiatric Association, 2013). ASD can co-occur with several other conditions such as attention deficit hyperactive disorder, seizures, and almost 70% of people with ASD also have learning disability (Levy, Mandell, & Schultz, 2009). The features of ASD start appearing very early in life as parents generally report lack of eye-contact, limited joint attention, pointing, and reciprocal smiling in children (Caronna, Milunsky, & Tager-Flusberg, 2008). These symptoms later result in social and communication difficulties. Social difficulties are the most pervasive problems experienced by individuals with ASD. These difficulties often persist despite improvements in other clinical features of the disorder (Baron-Cohen, 1988). It was recently suggested that people with ASD, may differ in their motivation to engage or affiliate with others (Chevallier, Kohls, et al., 2012; Klin et al., 2003; Russell-Smith, Bayliss, & Maybery, 2013). Measuring the motivational forces behind social preferences is important in the emerging study of social motivation. In the previous chapter, I discussed development and use of a novel Choose-a-Movie (CAM) paradigm to quantify preferences for social stimuli in typical adults. The results from that experiment showed that this simple computer tool can be used to measure social seeking aspect of motivation. It also showed a negative correlation between autistic traits and social seeking behaviour. This experiment aimed to explore if CAM paradigm could be used to measure seeking in a clinical population of adults with ASD.

Social motivation is divided into three components: social orientation, social seeking, and social maintaining (Chevallier, Kohls, et al., 2012). I will briefly explain these three components and will present recent literature evaluating them in ASD. First component, social orientation is defined as attentional priority for social cues or social information. Several studies suggest that people with ASD are less likely to spontaneously orient towards faces and social stimuli in their environment than typical controls (Klin et al., 2002; Schultz, 2005; Senju & Johnson, 2009). Second component, social maintaining is described as behaviours aimed at having long term social affiliation. Evidence suggest that children with ASD do not attempt to re-engage, if adult stops interacting suddenly, while such behaviour clearly elicits social initiation response in typically developing children (Liebal et al., 2008); children with ASD do not alter their social feedback to flatter another person (Chevallier, Molesworth, & Happé, 2012); and unlike typical adults who significantly change the donation they will make depending on presence or absence of observers, adults with ASD barely do so (Izuma et al., 2011). Third component, social seeking is a concept which is typically understood as liking a stimulus (getting hedonic pleasure from it) and wanting it (making an effort to get it). The present research focuses on this component of social motivation, which is discussed in detail in the next section.

Previous studies of social seeking in ASD have primarily used brain imaging and self-report measures to estimate reward value of social stimuli in ASD. The imaging studies suggest that there might be atypical activation in the 'reward related' brain structures during social interactions in ASD (Delmonte et al., 2012; Dichter, Richey, Rittenberg, Sabatino, & Bodfish, 2012; Kohls, Schulte-Rüther, et al., 2013; Scott-Van Zeeland et al., 2010). Studies using self-

report measures suggest that people with ASD experience less pleasure from social contacts (Chevallier, Grèzes, et al., 2012); and do not express loneliness despite reporting lower companionship and reciprocity in their peer networks (Chamberlain et al., 2007). These results are consistent with the theory of reduced social motivation in ASD. However these methods are limited as they can only be used to study a subgroup of people with ASD who have sufficient language and insight to complete self-report measures or are able to cope with brain scanning techniques.

Researchers have also used behavioural paradigms to explore the social seeking aspect of social motivation. One such paradigm was used by Ewing et al (2013) who measured the reward value for three categories of stimuli: Faces, inverted faces, and cars, in adolescents with ASD. Ewing et al used a keypress task in which participant needed to make effortful key presses to look at the images. The results from the study showed that adolescents with ASD as well as a matched control group made significantly more effort to look at the images of cars than faces or inverted faces. Furthermore, there was no significant difference between the groups for the amount of effort they made to look at the social stimuli. Hence this study did not entirely support the reduced social motivation theory of ASD. These findings also differ from the findings of previously discussed imaging studies using adults groups of ASD. A major limitation of the behavioural paradigm used in this study is that the critical stimuli were visible to the participant when they made a decision to view or avoid it. This means that participants could be choosing to view a particular image on the basis of any number of features, including low-level differences unrelated to social cognition.

Furthermore, none of the studies discussed above distinguish social seeking response between different types of social cues. Typical adults find direct gaze more rewarding than averted gaze (Kampe et al., 2001) while avoidance of eye contact is commonly reported in ASD, these studies do not explore differences in the social seeking motivation for direct gaze (highly engaging social interactions) vs averted gaze (low engaging social interactions).

One way to get around the problem of low-level features of stimuli influencing response of the participants can be to create an association between neutral cues and stimuli and ask participants to select from these cue stimuli which are linked to original stimuli. As associative learning has been found to be intact in individuals with autism (Happé, 1995; Preissler, 2008), a paradigm of this kind should be a suitable way to test for social seeking without the influence of lower level cues. In the present experiment CAM paradigm which is based on associative learning to quantify social seeking was sued with adults with ASD and matched controls. This paradigm presents both direct and averted gaze stimuli in order to quantify if differences in social motivation in ASD apply to all faces or only to direct gaze. On different trials, participants make choices to view between direct-gaze vs averted-gaze movies; direct-gaze vs object movies; averted-gaze vs object movies. Based on the previous findings with adults with ASD it is hypothesised that participants with ASD may have reduced social motivation.

3.3 Methods

3.3.1 Participants

Thirty adults with ASD (9 females) and 24 typical adults (10 females) between the ages 20-60 years participated in the study. The two groups were matched on verbal , performance, and full scale intelligence quotient using Wechsler Adult Intelligence Scale (WAIS) (Wechsler, 2011) see table 3.1. Participants were recruited from the autism / adult participants' database of the Institute of Cognitive Neuroscience, University College London.

Table 3.1 The description of groups and their comparison on age, intelligence, and autistic traits.

	ASD group N = 30	**Control Grp N=24**	**Difference**
M : F	ratio = 21:9	ratio = 14:10	χ^2 (1, N = 54) = 0.796, *p* = 0.40
Age (Years)	*M* =36.60, *SD* ±9.78	*M* =37.88, *SD* ±13.00	*t* (52) = -0.41, *p* = 0.683
Verbal IQ	*M*=117.83, *SD*±14.71	*M* =117.88, *SD* ±15.80	*t* (52)= 0.118, *p* = 0.907
Performance IQ	*M* = 110.17, *SD* ±14.66	*M* = 114.88, *SD* ±13.42	*t* (52) = -1.12, *p* = 0.269
Full IQ	*M* = 115.83, *SD* ±13.87	*M* = 118.04, *SD* ±12.79	*t* (52) = -0.455, *p* = 0.651
AQ	*N = 25, M* = 35.25, *SD* ±9.23	*N = 21, M* = 20.33, *SD* ±8.69	*t* (44) = 5.749, *p* < 0.0001

3.3.2 Procedure

Ethical approval for this experiment was provided by the University College London graduate school ethics committee. The study was conducted in accordance with the declaration of Helsinki. All the participants gave written informed consent to take part in the study. The participants in the ASD group all had an independent clinical diagnosis of ASD and all except one were evaluated on Autism Diagnostic Observation Schedule - ADOS (Lord et al., 2000). The ADOS scores showed that 12 participants qualified for the category of "autism" and 12 for the category of "autism spectrum disorders", five participants had very low scores thus not qualifying for either the 'autism' or 'autism spectrum disorder' category on ADOS. Irrespective of the ADOS scores all the participants in the ASD group had a clear diagnostic history and clinical diagnosis of ASDs from independent clinicians and were therefore included in the analysis. As an additional measure of autism severity we administered the "Adult Autism Spectrum Quotient " - AQ (Baron-Cohen et al., 2001) to all the participants and found that the ASD and non-ASD groups were significantly different (p <0.0001) on their mean AQ score. All the participants then completed the CAM paradigm in a lab setting as discussed in experiment 1 in chapter 2.

3.3.3 Data analyses

Data was analysed in the same way as described in experiment one. This was a mixed-levels model (generalised linear regression) using a logistic link function with participants' ID as a between-subjects factor, and age and gender as covariates. Main effects of effort, stimuli, and group and also for interactions

between these factors were tested. Data were analysed in SPSS and results are reported in terms of the Wald statistic.

3.4 Results

The data was analysed separately for the three sets of choices: Direct gaze vs object; averted gaze vs object; and direct gaze vs averted gaze. Results are shown in figure 3.1 and table 3.2. As we had a priory prediction about groups performing differently, an additional analysis using same logistic regression was also conducted separately for the typical and ASD groups. These results are presented in table 3.3. This analysis also helped in understanding the interaction effects found in the main analysis.

3.4.1 Direct gaze vs object movies

In the choice between direct gaze movies and objects, there was a main effect of effort on the choice (Wald $\chi^2 = 49.51$, $p < 0.0001$), an interaction of stimuli by group (Wald $\chi^2 = 3.10$, $p = .083$), interaction of effort by group (Wald $\chi^2 = 10.65$, $p = .031$), and a three-way interaction between effort, stimuli and diagnostic group (Wald $\chi^2 = 11.99$, $p = .017$). This can be seen in figure 3.1 as direct gaze movies are more often chosen in the typical group (red line higher than blue line) but are less often chosen in the ASD group (blue line higher). This shows that effort is a main variable influencing choice of both the groups; however the groups are not influenced by it in the same manner. The separate group analysis for this choice as shown in table 3.3 suggests that the effect of

effort is moderated by the preference for stimuli in the typical group but not in ASD group.

3.4.2 Averted gaze vs object movies

In the choice between averted gaze movies and objects, there was a main effect of effort on the choice (Wald $\chi^2 = 53.91$, $p < 0.0001$), but there were no reliable effects of group. This suggests that when presented the choice between averted gaze and object movies, participants of both the groups consider effort as an important factor while making the decision. The exploration of data for separate groups suggests that ASD group was influenced by the stimulus as well as effort but the typical group was only influenced by the effort. The figure 3.1 help in understating it further as it indicates that ASD group had a stronger preference for object movies in comparison to averted gaze movies (blue line is higher than the orange line and the gap between two lines is large), but they trade-off their stimuli preference for effort, however the typical groups did not have any preference for stimuli.

3.4.3 Direct gaze vs Averted gaze movies

In the choice between direct and averted gaze movies, there was a main effect of effort on the choice (Wald $\chi^2 = 44.25$, $p < 0.0001$), interaction effect of stimuli by effort (Wald $\chi^2 = 10.76$, $p = .029$), but there was only a marginal interaction between effort, stimuli and group (Wald $\chi^2 = 9.43$, $p = .051$). The separate group analysis shows that effort by stimulus interaction had a reliable effect on choice of both the groups (ASD: Wald $\chi^2 = 11.833$, $p = .019$) (Typical: Wald $\chi^2 = 11.259$, $p = .024$). The figure 3.1 further shows that typical group had

a strong preference for direct gaze stimuli which they trade-off against effort but preference for any one stimulus is not as strong for ASD group.

Analysis for none of choice pairs Direct gaze vs object; averted gaze vs object; and direct gaze vs averted gaze, showed main effect of age or full scale IQ that were entered as co-variable to the logistic regression.

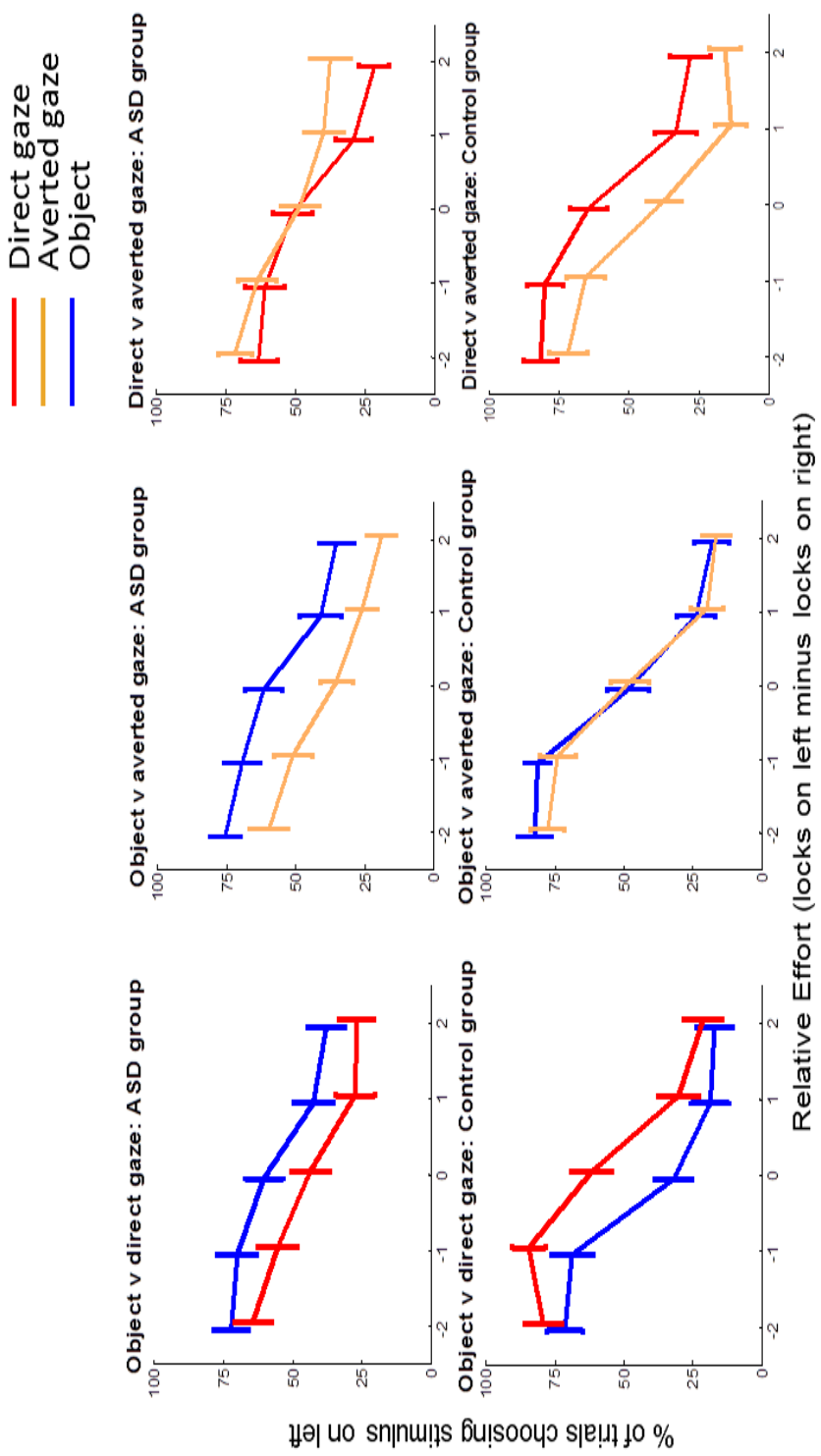

Figure 3.1: Choices in participants with ASD (top row) and without ASD bottom row). The x axis represents Effort and the lines show how often participants chose to view the movie on the left, for direct gaze (red), averted gaze (orange)

Table 3.2: Results from logistic regression: factors influencing participants' decision to choose stimuli on the left.

	Object v direct gaze (Wald χ^2 , *p*)	**Object v averted gaze (Wald χ^2 , *p*)**	**Direct v averted gaze (Wald χ^2 , *p*)**
Stimulus	0.022, $p = 0.883$	2.96, $p = 0.086$	0.65, $p = 0.422$
Effort	49.51, $p < 0.0001$	53.91, $p < 0.0001$	44.25, $p < 0.0001$
Group	0.354, $p = 0.552$	0.700, $p = 0.403$	0.014, $p = 0.906$
Stimulus X group	3.10, $p = 0.083$	0.99, $p = 0.320$	3.22, $p = 0.073$
Stimulus X effort	4.05, $p = 0.400$	0.45, $p = 0.978$	10.76, $p = 0.029$
Effort X group	10.65, $p = 0.031$	8.58, $p = 0.073$	4.25, $p = 0.373$
Stimulus X effort X group	11.99, $p = 0.017$	2.26, $p = 0.689$	9.43, $p = 0.051$
Age	1.65, $p = 0.199$	1.26, $p = 0.261$	1.45, $p = 0.228$
Full scale IQ	0.140, $p = 0.709$	0.011, $p = 0.918$	0.212, $p = 0.645$

Table 3.3: Logistic regression by group

	Object v direct gaze (Wald χ^2)		Object v averted gaze (Wald χ^2)		Direct v averted gaze (Wald χ^2)	
	Typical	**ASD**	**Typical**	**ASD**	**Typical**	**ASD**
Stimulus	1.417	1.670	0.228	4.346	2.672	0.664
	$p = 0.234$	$p = 0.196$	$p = 0.633$	$p = 0.037$	$p = 0.102$	$p = 0.415$
Effort	33.398	20.705	42.311	27.363	30.603	16.035
	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p = 0.003$
Stimulus	13.702	1.889	1.125	2.522	11.833	11.259
X effort	$p = 0.008$	$p = 0.756$	$p = 0.890$	$p = 0.641$	$p = 0.019$	$p = 0.024$

3.5 Discussion

This study aimed to explore if adults with ASD have reduced social motivation as suggested by the recent theory of Chevallier, Kohls, et al (2012). It is shown in this study that participants with a diagnosis of ASD have a reduced preference for direct gaze social stimuli. These data suggest that typical adults value direct gaze movies more than averted gaze, but prefer object movies as much as the averted gaze movies. On the other hand adults with ASD prefer the object movies more than averted gaze, but have no preference between direct gaze and averted gaze movies. The finding that social direct gaze is valued less in participants with ASD is compatible with a number of previous reports. Failure to make or respond to eye contact is a diagnostic indicator for ASD (American Psychiatric Association, 2013). Here it must be noted that the

previous studies which have measured social reward in ASD have used face stimuli with direct gaze, and so findings from those studies are compatible with the current data showing differences in the valuation of direct gaze stimuli (Delmonte et al., 2012; Kohls et al., 2013; Scott-Van Zeeland et al., 2010).

This experiment clearly demonstrates that the CAM paradigm can be used with adults with ASD as well as the typical adults. It provides a straightforward way to quantify social seeking in both the populations. The CAM paradigm targets social seeking aspect of social seeking that has been tested in very few behavioural studies. This data show that participants with ASD value objects more than social stimuli, while matched typical participants value direct gaze social stimuli more than objects.

Unlike the findings of the previous study with typical adults discussed in experiment 1 in chapter 2, results from this experiment suggest that participants with the diagnosis of ASD are influenced differently by both stimuli and effort resulting in an interaction between the two. However it is likely that this interaction is caused by the conditions in which participants are strongly driven by effort and show floor/ceiling effects for the −2/+2 lock conditions, meaning that stimulus effects are only visible in the intermediate conditions. The participants in this experiment completed the CAM paradigm as part of a day-long visit to the lab with many other experiments, so it is plausible to suggest they were heavily influenced by effort. Therefore, here the main effect of stimulus and a stimulus by effort interaction are interpreted in the same way. In the future, the levels of effort can also be increased to present a more extreme effort comparison such as one vs. ten locks, to allow a stronger effort effect.

The data from present experiment show that participants with ASD value object movies more than social movies. It is important to differentiate the

preference for rotating objects observed in this experiment from the general preference for repetitive movement as clinically observed in people with ASD. It is unlikely that the repetitive nature of stimuli might have influenced non-social preference in ASD in this study, as all three sets of stimuli had an equal number of different movies (ten social and ten objects). Furthermore, the object movies showed a single slow rotation ensuring that the object movies are not more repetitive than the social movies.

The reported preference for objects could be due to a general reduction in social motivation in ASD or to a more specific indifference towards direct gaze. Similar finding suggesting preference for non-social stimuli is also reported by Chevallier, Huguet, Happé, George, and Conty, (2013), however they found that within social stimuli people with ASD might prefer direct gaze stimuli more. In contrast, the results of the direct vs averted gaze comparisons in the present experiment show a marginal interaction with group and both groups show stimulus by effort interactions in opposite directions. This implies that typical and ASD participants value direct and averted gaze differently and supports the primary result that participants with ASD do not value social stimuli with direct gaze as much as typical adults. Similar findings have been reported earlier emphasising the significance of communication intent (Davies, Dapretto, Sigman, Sepeta, & Bookheimer, 2011) or approach motivation (Kylliäinen et al., 2012) through direct eye contact in typical people and lack of it in ASD.

Some studies suggests eye contact might be hyper-arousing for people with ASD (Joseph, Ehrman, McNally, & Keehn, 2008; Kylliäinen & Hietanen, 2006; but see Louwerse et al., 2013). However the present experiment does not support the idea of aversion to direct gaze in ASD. As in this experiment participants with ASD would sometimes choose to look at the direct gaze stimuli

if it required less effort than the other option. This implies that the lack of approach towards direct eye-gaze stimuli in ASD might be driven more by lack of interest in social interaction than by aversion from the eyes (Cohen, Vietze, Sudhalter, Jenkins, & Brown, 1989). When given the opportunity to view movies without direct gaze, the participants with ASD in the present experiment did not differ from the typical participants. However, note that the typical participants in this experiment did not show the same preference for averted gaze movies as seen in the previous experiment (discussed in chapter 2) this could be due to differences in the age, IQ or demographics between studies, or to the smaller sample size in the present study. Further investigation of how both typical and participants with ASD value social stimuli that do not involve direct gaze would be valuable. In particular, it would be useful to test the breadth of differences in social motivation – do participants with ASD avoid all social stimuli, or only those that directly signal engagement?

3.6 Conclusions

Overall, these findings suggest that the value of social stimuli in ASD can be measured using a simple behavioural method, which controls for lower level visual features of the stimuli and gives a precise measure of social seeking. This experiment demonstrates the clinical importance of this approach by quantifying how people with ASD value movies of direct gaze less than typical participants. This could be due to a general difference in social motivation, or it could be due to a more specific difference in the value of direct gaze itself. Further investigation of these two possibilities will be needed. In future, the CAM paradigm might be a helpful tool for estimating

the expected efficacy of social reward-based behavioural intervention used for developmental or psychiatric disorders.

CHAPTER 4: ADOLESCENTS WITH ASD SHOW LOW SOCIAL PREFERENCE BUT TYPICAL ADOLESCENTS SHOW NO PREFERENCE

4.1 Abstract

Previous studies suggest that social difficulties in Autism spectrum disorders (ASD) might be caused by the lower motivation to engage in social interactions. There are several studies supporting this theory for adults with ASD. However, there are inconsistent findings about social motivation in adolescents with ASD. In the current experiment, forty adolescents with ASD and 40 matched (age, verbal, non-verbal intelligence) adolescents participated. These groups were tested on the Choose a Movie (CAM) paradigm, which has previously been shown to be efficient in measuring the social seeking component of social motivation in adults with ASD. Participants were presented with the choice between social and non-social stimuli with different levels of effort to measure their social seeking. The results from this experiment showed that adolescents with ASD preferred non-social stimuli over social and they made a trade-off between their stimuli preference and the effort. On the other hand, the matched control group did not show any preference. They were primarily influenced by the effort while making their decision. The results also showed a significant role of intelligence in moderating the choice behaviour of the participants. Those with lower intelligence made decisions influenced by only one factor, whereas those having higher intelligence made decisions considering all the available factors.

On the whole results from this experiment support the theory of reduced social motivation in ASD, but these findings raised some important questions about developmental changes in social motivation in typical people during adolescence, and the role of intelligence in influencing people's decision about effortful social interactions.

4.2 Introduction

Social difficulties are one of the core features of autism spectrum disorders (ASD). This is one set of difficulties that pervades the complete spectrum and is generally most difficult to deal with. Several theories have been proposed to understand the causes behind social difficulties in ASD. Some of these theories focus on executive function deficits (Ozonoff et al., 1991) and other on the social-cognitive aspects such as difficulty empathising, understanding what others think or feel (Baron-Cohen, Leslie, & Frith, 1985). Recently a theory about reduced social motivation in ASD has also been proposed to explain these difficulties (Chevallier, Kohls, et al., 2012). This theory emphasis that social interactions are inherently rewarding and motivating for most typically developing people but this might not be true for people with ASD. It suggests that reduced social motivation might be one of the primary reasons underlying social difficulties in ASD.

Reduced social motivation in ASD might be explained as low reward value of social interactions for this group. In the previous experiments discussed in chapter 2 and 3, I introduced a novel Choose-a-Movie (CAM) paradigm to measure social seeking component of social motivation in adults with and without ASD (Dubey et al., 2015). The findings from the experiment reported in

chapter 3, showed a preference for non-social stimuli over social in adults with ASD. On the other hand typical adults showed preference for social stimuli over non-social. However, both the groups also attempted to make minimum effort by trading-off their stimuli preference for the amount of work involved. Overall, these findings suggested that adults with ASD value social stimuli less than typical adults. Low value of social stimuli in ASD was also observed by Delmonte et al (2012) who used a Social Incentive Delay (SID) task with ASD and matched typical participants between ages 13 to 26 years. They found that the ASD group showed reduced brain activation in response to social reward compared to matched typicals.

The neuroimaging studies evaluating value of social stimuli in children with ASD also show findings consistent with the adult studies (Choi et al., 2015; Stavropoulos & Carver, 2014). Study by Choi et al (2015) showed that children with ASD between ages 7-9 years, when tested on a task about locating source of sound to measure value of social rewards, showed lower reward learning related brain activation for social condition than non-social. Similarly, a study by Stavropoulos and Carver (2014) measured reward anticipation responses in 6-8 year old children with ASD using ERP with 'guessing the right box' task. The results showed a smaller response to social but not non-social feedback in those with ASD.

The above discussed findings clearly suggest lower reward value of social stimuli in adults and children with ASD. However, the findings reported in the literature are not as consistent for the adolescent participants with ASD. For example, Ewing et al (2013) reported that adolescents with ASD did not differ from the control group in their preference for social or non-social stimuli. In fact both the groups showed a significantly high preference for non-social stimuli.

These findings suggest that these groups might not be different in their motivation to look at social stimuli but both the groups might be more motivated to look at non-social stimuli. Ewing et al suggested that preference for non-social stimuli in their sample might also be due to the preponderence of male participants, who typically prefer to play with cars (the non-social stimuli used in this study) than dolls. Here it is important to emphasise that the task used by Ewing et al did not present these stimuli competing against each other. Only one stimulus was presented in each trial and therefore the preference for any stimulus was its preference against blank screen or 'nothing' and not against other stimuli. Therefore, showing a strong preference for cars should not decrease the individual's preference for social stimuli as these stimuli were presented independently. This could mean that the reduced preference for social stimuli in both the typical and ASD adolescents might reflect lower social motivation rather than just a gender based effect. A recent study by Watson et al (2015) overcame this limitation by presenting a forced choice paradigm to adolescents with ASD and matched control. They reported that unlike matched controls, the ASD group preferred non-social stimuli over social only if non-social objects were of high interest to them. The two comparison groups i.e. ASD and matched typicals, once again did not differ in their preference for social and low autism interest non-social stimuli.

The neuroimaging studies for this age group also demonstrated findings different from adults with ASD. The studies using neuroimaging with adults (Dichter et al., 2012), and children (6-8 years) (Stavropoulos & Carver, 2014) with ASD suggest that they show specific reduced reward related activation for social conditions. These findings are replicated for adolescents (10-19 years) with ASD by Scott-Van Zeeland et al (2010), but not by the other studies. Two

different studies used an incentive go/no-go task with 9-18 year old children and adolescents with ASD (Kohls et al., 2011; Kohls, Schulte-Rüther, et al., 2013). The incentive go/no-go task is very similar to the SID task. It has different blocks of social, non-social reward conditions, and at the beginning of each block the participant is informed about what kind of reward he will get. As the trial begins, participant is presented a cue that indicates whether he should press or not the key on seeing the target. The key hit or no hit is then followed by the presentation of an image of the anticipated reward. In social conditions the reward image shows a smiling person and in non-social condition it is an image of money. Participant's reaction time for the correct responses is recorded to estimate his motivation to seek the reward. In one of these studies Kohls et al (2011) used incentive task with EEG and in the other (Kohls et al., 2013) they used it with the fMRI. In both the studies participants with ASD showed a generalised hypo-actiavtion for both social and non-social reward conditions. In the EEG based study they showed an attenuated P3 activity which indicates deminshed motivational attention to the stimuli and in the fMRI based study they showed hypoactivation of the reward related brain areas such as amygdala and anterior cingulate cortex. These findings are replicated by Damiano et al (2015) who used fMRI with negative reinforcement based SID task in a group of 9-18 year old participants with and without ASD, and suggested that they show reduced activation in the region of interest (right caudate nucleus, the area responsible for feedback learning) in anticipation of both social and monetary negative reinforcements in comparison to matched controls.

The above discussed studies seem to suggest that unlike adults and children, adolescents with ASD may have overall generalised low reward activation and not a specific deficit in social reward activations. Here it needs to

be noted that all the above reported studies have participants with high / average intellectual functioning. Hence it remains a possibility that reduced motivation, specifically for social reward, may be evident in those with ASD who are lower functioning and have cognitive delay.

The CAM paradigm is a simple computer task which can easily be adapted to be used with participants with limited cognitive abilities. In the current experiment I aimed to use a modified version of the CAM paradigm to explore social seeking in adolescents with and without ASD with a wide range of cognitive abilities. Based on the theory of reduced social motivation and the previous findings from the original version of CAM paradigm with adults with ASD, it was expected that the adolescents with ASD would show reduced preference for social stimuli.

4.3 Method

4.3.1 Participants

Two groups of 40 adolescents participated in the experiment. All of the 40 participants in the ASD group had received a clinical diagnosis of ASDs except one described below in section 4.3.1.1 "*Autism Spectrum Disorder (ASD) group*". The other group which also had 40 adolescents formed the matched control group. None of the participants in the control group had a diagnosis of any psychiatric condition. All of these 80 participants were recruited by contacting schools in Nottinghamshire. Written informed consent was taken from the participants' primary caretakers (parents). The groups were matched on their chronological age, verbal ability using British Picture Vocabulary Scale (BPVS III) (Dunn, Dunn, Whetton, & Burley, 1997), and for their non-verbal

ability using Raven's Progressive Matrices (RPM) (Raven, Court, & Raven, 2003). Participants with ASD were also rated by their primary caretakers on Social Responsiveness Scale- SRS (Constantino & Gruber, 2005), and Social Aptitude Scale –SAS (Liddle, Batty, & Goodman, 2009).

4.3.1.1. Autism Spectrum Disorder (ASD) group: All except one participant of the ASD group had a clinical diagnosis of ASD. The participant who did not have a formal clinical diagnosis was studying at a school that specialises in autism and communication disorders. He was undergoing an assessment for ASD through the NHS and had score above the cut-off for ASD on SRS (Constantino & Gruber, 2005), therefore indicating social difficulties characterising of ASD. All the other participants had an independent, NHS diagnosis of ASD. They were included irrespective of the sub-category of the diagnosis within ASD and associated conditions. Fourteen of these participants had no additional diagnosis, and details about the presence of any additional diagnosis were not available for five participants. Other participants had one or more additional conditions, including Attention Deficit Hyperactive Disorder (n=9), learning disability (n=7), dyspraxia (n=6), anxiety disorder (n=3) and other conditions (n=13) such as Tourette syndrome, and epilepsy.

Table 4.1: Group description for all the participants. Here *N* represents the available data for the subgroups. Raw score were used for BPVS, RPM, SRS and SAS.

	ASD group	Control Group	Difference
M : F	*N*=40, ratio = 35:5	*N* =40, ratio = 36:4	
Age (Years)	*N* =39, *M* =14.28, *SD* ±1.94	*N* =39, *M* =13.73, *SD* ±1.08	*t* (61.10) = 1.57, *p* = 0.122
BPVS	*N* =36, *M* =126.73, *SD* ±26.30	*N* =40, *M* =137.35, *SD* ±10.23	*t* (50.54)= -2.38, *p* = 0.021
RPM	*N* =35, *M* = 37.14, *SD* ±9.58	*N* =39, *M* =39.46, *SD* ±7.25	*t* (78) = -1.22, *p* = 0.226
SRS	*N* =32, *M* = 114.31, *SD* ±25.14		
SAS	*N* =33, *M* =7.48, *SD* ±5.77		

4.3.2 Materials

The primary caretakers of the participants returned the completed SRS (Constantino & Gruber, 2005) and SAS (Liddle et al., 2009) for the participants with ASD. BPVS III (Dunn et al., 1997) was used to evaluate verbal ability, RPM (Raven et al., 2003) to measure non-verbal intelligence. An adapted version of Choose a Movie (CAM) paradigm was presented to the participants using MATLAB with Cogent toolbox on 12 x 6.5 inch screen of a Samsung Ultrabook (touch screen). Details of the paradigm are given below.

4.3.2.1 Adapted Choose-a-Movie (CAM) paradigm: Like the original version of the CAM paradigm (Dubey et al., 2015) also discussed in chapter 1, on each trial two boxes (9.5 x 7.5 cm) were presented side by side with small images of locks over them. Participants made their choice by removing the locks of the selected box which then revealed a movie (11 x 8 cm) appeared at the centre of the screen. Each movie played for only three seconds. The paradigm was slightly modified from its original version to suit the attention span of a younger population. Participants were presented with the choice between only social and non-social stimuli, and rather than using keypresses the task was changed to use touches on the touch sensitive screen. Furthermore, to make sure that participants learned the association between the coloured boxes and the stimuli, they completed 10 associative learning trials and an additional set of 2 instruction trials. In the additional instruction trials, the boxes (one at a time) appeared on the left side of the screen and the participant was asked to touch it to see what kind of stimuli were linked with it. When the participant touched the screen, six images of linked stimuli appeared on the right hand side of the screen. The box and images remained on the screen for three seconds (e.g. see figure 4.1).

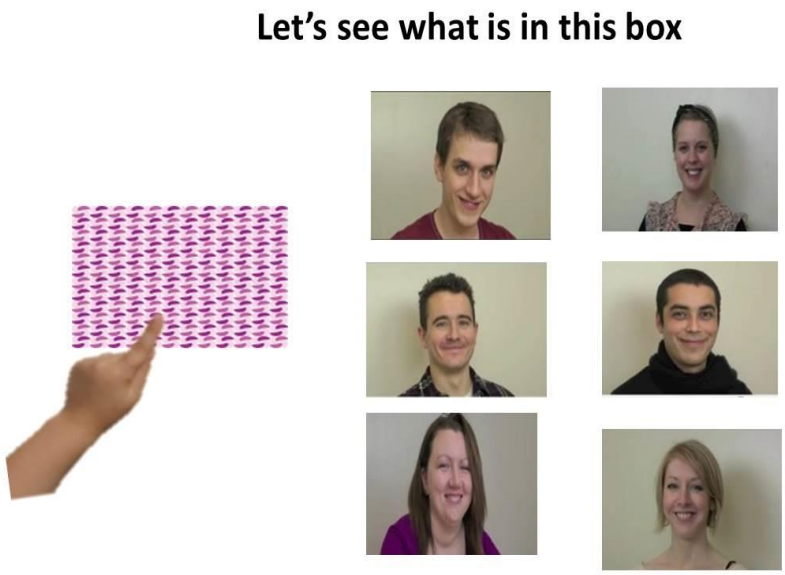

Figure 4.1: Example of additional instruction trial added to ensure the participant knows the link between coloured cue box and the stimuli type.

After the additional learning trials, participants moved on to the associative learning trials, which were the same as the original version of the paradigm. There were 10 associative learning trials. On these trials, only one box with a single lock was presented on the screen (figure 4.2). The participant touched the lock to remove it. Once the lock was removed the participant watched one of the linked movies. This gave participants a chance to become familiar with the two types of boxes and their linked movie categories.

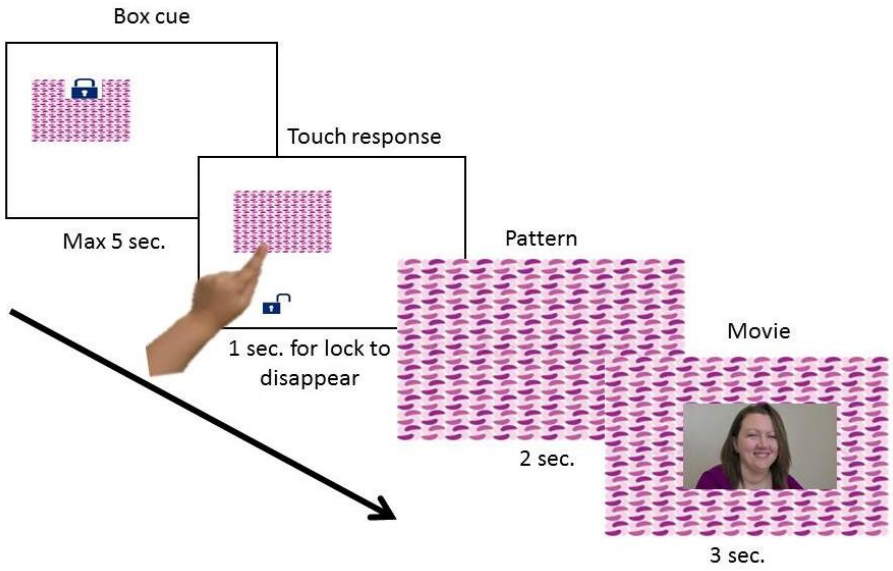

Figure 4.2: Example of an associative learning trial. Here participant sees only one box.

Subsequently participants completed 60 experimental choice trials. On each trial, participants saw two boxes on the screen with between 1 and 3 locks on each box. Participants chose any one box and removed the locks by touching them. When all the locks on any one box were removed, that box opened to show a movie from the associated set of stimuli (figure 4.3). There was a consistent mapping between the coloured boxes and the category of movies which were shown when these boxes opened. For example, opening the orange stripy box would reveal one movie randomly chosen from the 'social' category, while opening the pink spotty box would reveal one movie randomly chosen from the 'object' category. The mapping between the box pattern and the movie category was constant for each participant and counterbalanced across participants.

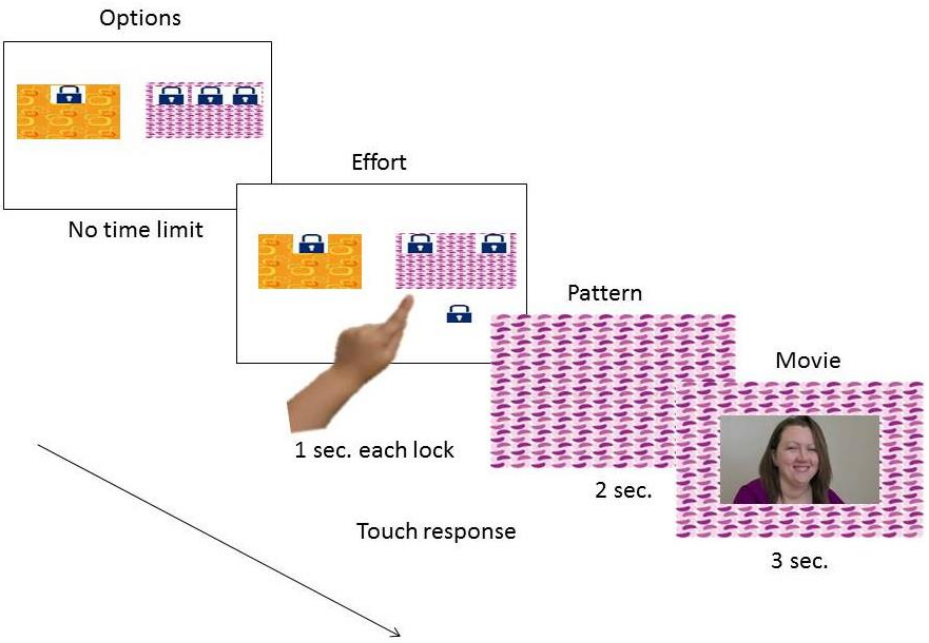

Figure 4.3: Example of an experimental choice trial in which participant is presented with box with object movies with one lock and box with social movies with three locks. Participant here touched the pink (social) box to open, making relatively higher effort (+2 locks) to look at a movie from his/her preferred stimuli category.

The 60 choice trials had 24 trials which showed 3 locks on one box and 1 on the other; 12 showed 2 locks on one box with 1 on the other, 12 showed 3 locks on one box with 2 on the other, and 12 showed equal numbers of locks on each box. The boxes with the larger number of locks were pseudo-randomly assigned to the left or right side of the screen with equal probability for appearing on both sides. On each trial, a participant could choose to open the box with fewer locks (fewer touches and quicker) or the box with more locks (more touches and slower). Thus, participants were encouraged to make a

trade-off between the effort required to open the box and their preference for a particular movie category.

4.3.3 Procedure

The primary caretakers of the participant were contacted and consent was obtained. The caretakers were also sent two questionnaires (SRS and SAS) to evaluate social functioning of the participants. The rest of the evaluation was completed with the participant in multiple one-to-one sessions. The sessions were administered in a quiet room in the school with little distraction. The sequence of administration of these tasks could vary depending on the schedule of the school and availability of the participant. The participants were given breaks between the tasks (when needed). Due to long testing sessions some participants could not complete all the tests. The data is missing for: Age - ASD = 1/ control =1; BPVS - ASD =4 / control =0 ; RPM - ASD =5 / control = 1; SRS - ASD = 8; and SAS - ASD = 7. The missing values on measures of age, BPVS, RPM, SRS and SAS were replaced by the group means.

4.4 Results

4.4.1 Logistic regression analysis

To understand the predictive value of effort, stimuli, groups, and their interaction on the choice made by the participants, mixed model logistic regression analysis was used. Here only main results are discussed and all the other results are presented in table 4.2 and 4.3. The results suggest that the choices of the participants were influenced primarily by the effort on the trials (Wald χ^2= 40.044, $p < .0001$), and marginally by the stimuli (Wald χ^2 = 3.739, p

= 0.053). There was also a trend towards significant interaction between effort and group (Wald χ^2 = 8.352, p = 0.080).

Table 4.2: Results from logistic regression: factors influencing participants' decision to choose stimuli presented on left side.

	All participants (Wald χ^2, p)
Effort	40.044, p < .0001
Stimuli	3.739, p = 0.053
Groups	2.026, p = 0.155
Stimuli X effort	5.759, p = 0.218
Stimuli X group	1.401, p = 0.237
Effort X group	8.352, p = 0.080
Stimuli X effort X group	7.618, p = 0.107

To explore the choice patterns of each group, the logistic regression for each group was used separately. The results (table 4.3) showed that the choices made by the ASD group were significantly influenced by the effort (Wald χ^2 = 19.388, p = 0.001) and stimuli (Wald χ^2 = 4.309, p = 0.038), but not by their interaction. On the other hand, choices of the matched typical group were significantly influenced by the effort (Wald χ^2 = 23.867, p < 0.0001), and an interaction between effort and stimuli (Wald χ^2 = 14.723, p = 0.005).

Table 4.3: Logistic regression by group

	Object v direct gaze (Wald χ^2, *p*)	
	ASD	**Matched control**
Effort	19.388, $p = 0.001$	23.867, $p < 0.0001$
Stimuli	4.309, $p = 0.038$	0.323, $p = 0.570$
Stimulus X effort	0.958, $p = 0.916$	14.723, $p = 0.005$

Overall these results suggest that choices made by both the groups were influenced by the effort involved in each trial, however the ASD group preferred non-social stimuli over social stimuli (see figure 4.4). To look at their preferred stimuli while making less effort they made a trade-off between the two factors. On the other hand, the typical group did not have any consistent stimuli preference. Their preference for non-social stimuli is higher when stimuli were presented with low effort and the opposite pattern is observed on high effort trials (figure 4.4). Despite some influence of stimuli type their behaviour largely seems to be influenced by the effort involved in the trials. It is also likely that the interaction between stimulus and effort was caused more by the data from the participants who are influenced primarily by the effort and hence reached a ceiling effect. In figure 4.4, the x axis shows the relative effort on the left side on each trial and the y axis shows the percentage of time a stimuli was chosen.

The blue line shows the preference for object and green line shows the preference for social stimuli. The difference between the two lines hence shows the extent of preference for one stimulus over the other (larger the difference stronger the preference).

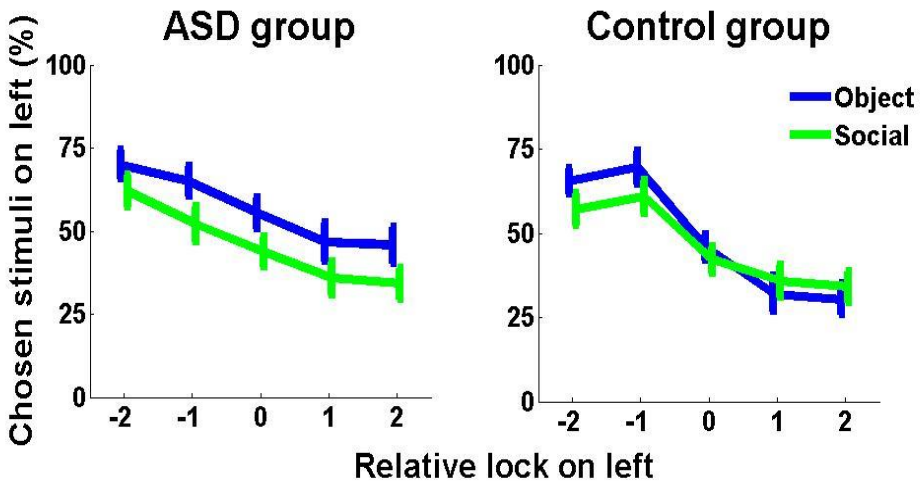

Figure 4.4: Figure shows mean percentage (Y axes) of times participants from each group chose social (green line) or non-social (blue line) stimuli when presented on left side with relative lock difference (effort) of -2 to +2 (X axes). Here a -2 relative lock difference indicates that there was 1 lock on the left side and 3 on the right side.

To explore the role of other factors such as intelligence or age on the choice behaviour of the participants a few more logistic regression analyses were conducted taking these factors in account. The results from them are presented below in tables 4.4. The term 'factor' in the column one of this table refers to the three different factors shown in three columns i.e. age, RPM, and BPVS.

Table 4.4: Logistic regression with other factors namely age, non-verbal intelligence (RPM), and verbal intelligence.

Factors	**Age**	**RPM**	**BPVS**
Effort	11.231, $p = 0.024$	20.486, $p < 0.0001$	13.311, $p = 0.010$
Stimuli	0.237, $p = 0.626$	0.718, $p = 0.397$	0.444, $p = 0.505$
Group	0.805, $p = 0.370$	0.072, $p = 0.788$	2.392, $p = 0.122$
Stimulus X effort	5.838, $p = 0.212$	5.993, $p = 0.200$	3.509, $p = 0.476$
Stimuli X group	2.551, $p = 0.110$	1.543, $p = 0.214$	0.236, $p = 0.627$
Effort X group	0.841, $p = 0.937$	10.949, $p = 0.027$	11.835, $p = 0.019$
Effort X stimuli X group	5.539, $p = 0.236$	1.752, $p = 0.781$	1.056, $p = 0.901$
Effort X *factor*	7.855, $p = 0.097$	13.936, $p = 0.008$	9.117, $p = 0.058$
Stimuli X *factor*	0.116, $p = 0.734$	0.197, $p = 0.657$	0.864, $p = 0.353$
Effort X stimuli X *factor*	5.678, $p = 0.224$	5.238, $p = 0.264$	3.268, $p = 0.514$
Stimuli X group X *factor*	2.901, $p = 0.089$	2.201, $p = 0.138$	0.450, $p = 0.502$
Effort X group X *factor*	1.262, $p = 0.868$	10.282, $p = 0.036$	11.714, $p = 0.020$
Effort X stimuli X group X *factor*	5.590, $p = 0.232$	1.066, $p = 0.900$	1.004, $p = 0.909$

The results from table 4.4 suggest that though effort still remained the most important variable influencing the choice behaviour but intelligence might moderate its effect on the choice behaviour. To further understand this effect a median split was carried out on the RPM and BPVS scores which were then plotted against the effort and the stimuli choice for the subgroups of high and low intelligence scores (figure 4.3).

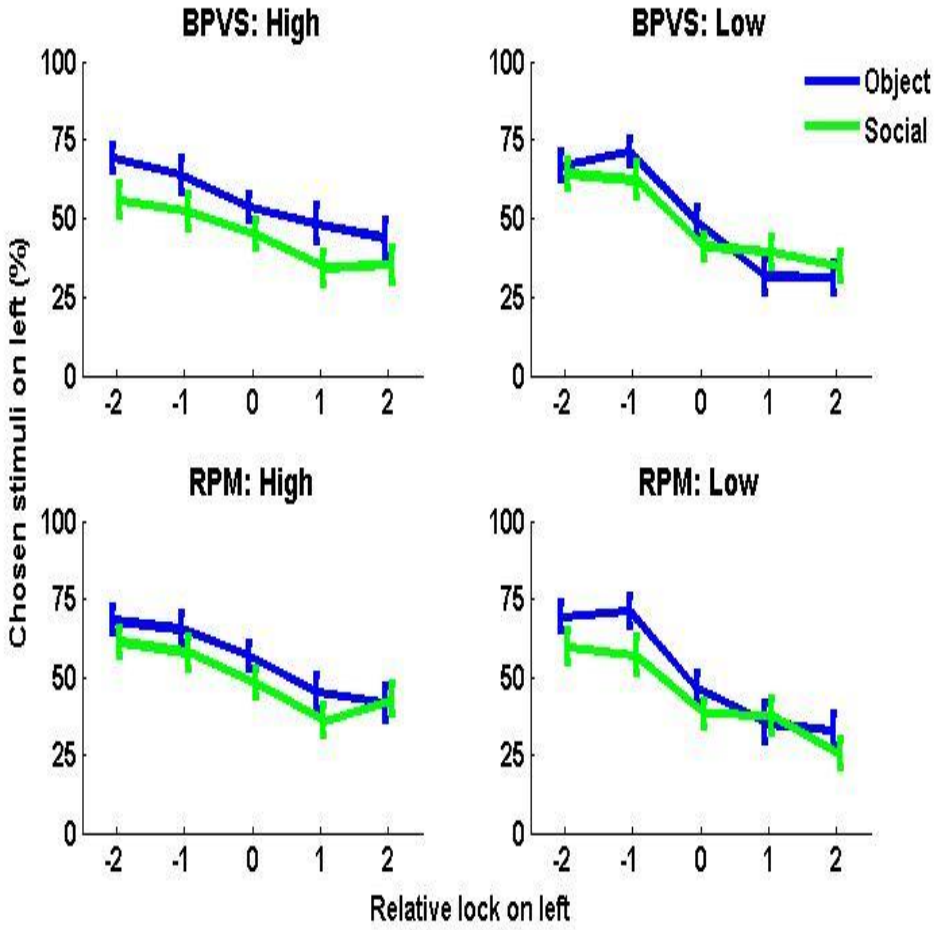

Figure 4.5: Figure shows the relation between median split of intelligence scores (as evaluated on BPVS and RPM) and the preference for two stimuli over different levels of effort.

The figure 4.5 shows steeper slope for the participants with lower verbal and non-verbal intelligence indicating higher influence of effort on their decisions, while the slope is shallow for the participants with higher intelligence score. Though in this figure it appears that the participants with higher intelligence scores prefer non-social over social stimuli, the regression analysis does not indicate any significant stimuli preference for these subgroups.

4.4.2 Supplementary analysis with the matched data sets

As the two groups did not match on BPVS a separate analysis was done by matching them. To match the groups in this second analysis, 8 ASD participants and 3 from the typical group were excluded. The description of the matched groups is given in table 4.5 and the findings of the logistic regression for the matched group are presented in table 4.6. The main results from the logistic regression (with unmatched groups) were largely the same after matching the groups on BPVS except the marginal effect of effort by group interaction was no longer significant.

Table 4.5: Description of the matched groups. Raw score were used for BPVS and RPM.

	ASD group n=32 M(± SD)	**Typical Group n=37 M(± SD)**	**Difference**
Age (Yrs)	14.32 (±1.89)	13.74 (±1.12)	t (67) = 1.603, p = 0.114
BPVS	130.44(±25.76)	136.70 (±9.65)	t (67)= -1.373, p = 0.174
RPM	37.38 (±10.13)	39 (±7.25)	t (67) = -0.773, p = 0.442

Table 4.6: Results from logistic regression for the matched groups: factors influencing participants' decision to choose stimuli presented on left side.

	Matched participants (Wald χ^2, *p*)
Effort	37.477, $p < .0001$
Stimuli	3.783, $p = 0.052$
Groups	1.823, $p = 0.177$
Stimuli X effort	3.535, $p = 0.473$
Stimuli X group	2.096, $p = 0.148$
Effort X group	7.682, $p = 0.104$
Stimuli X effort X group	6.116, $p = 0.191$

4.5 Discussion

The aim of this experiment was to explore the social motivation in adolescents with and without ASD. The two groups of adolescents were matched on their chronological age, gender ratio, verbal, and non-verbal intelligence score. Findings suggest that for the ASD group, stimulus was a major factor influencing choice, whereas for typical group influence of the stimulus was moderated by the effort involved in the trials. These findings suggests that adolescents with ASD prefer non-social stimuli over social stimuli but they trade-off their stimuli preference with the effort. In contrast the typical

group is largely influenced by the effort, though they show no consistent preference for any one stimulus. In an additional analysis the role of age and intelligence on the choice behaviour of the participants was explored. The results suggest that intelligence may have influenced participants' choices about the effort they chose to make. I will first discuss the findings about social preference in the two groups, and then the role of intelligence on the choice behaviour of the participants.

4.5.1 Social preference in participants with and without ASD

Results from the logistic regression suggest that participants with ASD prefer non-social stimuli over social irrespective of the effort involved in the task. Yet they are not completely indifferent to the effort involved in their choice. They trade-off their preference for non-social stimuli with the effort. These results are very similar to what was observed in the previous study using CAM paradigm with adults with ASD (Dubey et al., 2015).

Like some of the previous studies with adolescents with ASD (Ewing et al., 2013; Watson et al., 2015), despite the higher preference for non-social than social stimuli in ASD group, there was no significant difference in the social preference of ASD and typical groups in the current experiment. Here the lack of difference between the groups was caused by the no stimuli preference in the typical group rather than high social seeking in the ASD group. The motivational changes in typical people during adolescence have also been reported in a brain imaging study (Bjork et al., 2004). In this study 12-17 years olds showed selectively reduced activation in Ventral Striatum (region for motivation) for anticipation of social reward but no difference in brain activation for consumption (final presentation) of social reward. These results indicate that

though typical adolescents may not have lower liking for social stimuli than adults but they may not seek it as much as adults do. Similar conclusion was drawn from the behavioural study by Kohls, Peltzer, Herpertz-Dahlmann, and Konrad (2009) and Demurie, Roeyers, Baeyens, and Sonuga-Barke (2012) who used the Social Incentive Delay task with typical adolescents (between 8-12 and 8-16 years respectively). Both these studies reported that the social rewards did not improve the task performance for this group. Demurie et al (2012) further reported that the participants showed higher liking for social stimuli but it had no positive relation with their reaction time while anticipating social rewards. Unfortunately, in the current experiment no independent rating of liking for the stimuli was taken from the participants, therefore it is difficult to conclude if there was any disparity between liking and wanting of social stimuli in the typical group of adolescents.

As put together the findings from this and the other similar studies with adults and children with ASD (Choi et al., 2015; Delmonte et al., 2012; Dubey et al., 2015; Stavropoulos & Carver, 2014), suggest that the preference for non-social stimuli in ASD does exist from childhood through to adulthood. However, there might be a lack of preference for social stimuli in the typical group, as suggested by the current experiment, Ewing et al (2013), and Kohls et al (2009). It might be that typical adolescents undergo change in their social motivation during this age, which dampens the difference between ASD and typical adolescents, giving a false impression of 'typical social preference in ASD' even when there is no change in social motivation of this group. I will further examine the effect of age on the social motivation of typical adolescents in the next chapter.

4.5.2 Role of intelligence in determining social preference in participants with and without ASD

In the current experiment, intelligence measures were taken primarily to match the two groups for their intellectual abilities, however an additional analysis suggested that intelligence can be a major factor influencing the choice behaviour of the participants. Figure 4.3 shows that participants with higher verbal and non-verbal intelligence have lower influence of effort on their choice behaviour than participants with lower intelligence. In other words participants with higher intelligence are more likely to choose the option with higher effort than participants with lower intelligence. The preference for 'costly signals' i.e. the options that may demand more effort or risk has been earlier reported in relation to high intelligence in typically developing people (Millet & Dewitte, 2007). It is proposed that people with higher intelligence have higher self-control and they can weigh the factors influencing their choice more carefully. Contrary to that, people with lower intelligence tend to choose the options that result in immediate reward (Osiński, Ostaszewski, & Karbowski, 2014). This is also consistent with the choice behaviour of the participants with lower intelligence in the current experiment. As suggested by figure 4.3 participants with lower intelligence were highly influenced by the effort involved in the task than the other subgroup. The tendency to seek immediate and easier rewards in people with lower intelligence has been attributed to the limited working memory ability in this group (Shamosh & Gray, 2008). Shamosh and Gray propose that memory plays a crucial role in holding the mental image of the preferred reward while other factors are evaluated to reach the final decision. In absence of this capacity person may not be able to hold this information and might be influenced by either one or the other factor, which might also explain the

significant effect of effort in the typical group with lower RPM and BPVS scores in this experiment. Though these explanations may partially help understanding the choice behaviour of the participants in the current experiment, they need to be explored more in the future studies.

4.6 Conclusion

To summarise it can be concluded from this experiment that adolescents with ASD show low social preference on CAM paradigm, supporting the theory of reduced social motivation in ASD. However, the difference between the social preference for ASD and typical group may diminish during this age due to changes in the social preference in the typical group. These findings have strong implication for future research exploring group difference between social behaviour of typical and ASD groups. The typical group which serves as a reference to 'normal' social behaviour might as well be undergoing major changes in their social cognition and behaviour. Hence the difference between the groups specially if compared longitudinally might incorrectly suggest near typical performance for ASD adolescents even when they do not improve from their previous performance. In the next chapter I will explore the developmental changes in social seeking behaviour and will evaluate alternative explanations to understand it.

The other findings from the current experiment suggest that intelligence might play a crucial role in the choice behaviour of adolescents, which needs to be explored more extensively in future.

CHAPTER 5: SOCIAL MOTIVATION DECLINES DURING PREADOLESCENCE

5.1 Abstract

The desire to engage with others is an important motivational force throughout our lifespan. Reduced interest in social interactions might contribute to the social difficulties in clinical conditions like autism spectrum disorders and schizophrenia. Therefore it is important to understand the developmental time-course of the motivation to interact socially. In this study “Choose a Movie” (CAM) paradigm was used to quantify the motivation to seek social stimuli, in more than 250 typically developing participants from ages 4-20 years. Data from 153 typical children between ages 4-11 years was collected for this study and this was added to the data from the typically developing adolescents and adults between ages 11-20 year who originally participated in different experiments. All these participants completed CAM task and were evaluated for the choice between social direct gaze vs object trials. The results from this collated data suggest that both young children (4-8years) and young adults (16-20 years) preferred viewing movies of smiling adults to movies of household objects. Surprisingly, this preference declined during preadolescence (around 11/12 years), giving a U-shaped developmental trajectory over the whole population. This data present the first evidence for non-monotonic developmental change in social seeking in typical participants. These results can help our understanding of changes in social behaviour in typical development

and have important implications for research focusing on social development and social cognition.

5.2 Introduction

Human social interactions depend on both abilities and motivations, including recognition of faces and emotions, understanding of other's thoughts and the desire to engage with other people. Recent work suggests that some aspects of social cognition develop non-linearly over childhood, which has both cognitive and clinical implications. Performance on face recognition tasks dips around age 12 years (Carey, Diamond, & Woods, 1980; Lawrence et al., 2008); emotion recognition performance may dip around adolescence (McGivern, Andersen, Byrd, Mutter, & Reilly, 2002; Ross, Polson, & Grosbras, 2012, but see Herba, Landau, Russell, Ecker, & Phillips, 2006); and preference for 'attractive' facial features increases between ages 4-9 years but dips at 10-14 years before reaching adult levels (Boothroyd, Meins, Vukovic, & Burt, 2014). The non-monotonic development of skills is not only characteristic of typical development but is also observed in different clinical conditions. For example, a meta-analysis exploring neurocognitive abilities (such as response inhibition, attention, attention shift, working memory) attention suggests that this may have a non-linear developmental trajectory in ADHD (Pauli-Pott & Becker, 2011). Similarly people with schizophrenia show decline in cognitive skills before onset of illness, in addition to the existing initial lag (Bora, 2014). Hence, it is essential for clinicians to explore how different developmental trajectories of social abilities relate to the manifestation of clinical symptoms.

While the development of cognitive and information processing has been examined as described above, motivational processes have received less attention. There is now increased interest in quantifying and understanding core motivational processes underlying social development, which is also the key focus of the this chapter. The process of identifying the social cues from the environment (social orienting), making effort to seek pleasurable social interactions (social seeking), and making efforts to foster and maintain social bonds (social maintaining) are components that constitute social motivation (Chevallier, Kohls, et al., 2012). Social orienting is the ability to identify and orient to social cues, typically measured with eye-tracking or gaze tasks. It is present from birth (Di Giorgio et al., 2012; Frank et al., 2014; Gliga et al., 2009) and throughout childhood and adulthood (Fletcher-Watson et al., 2008; Wilson et al., 2010), but has not been measured systematically with the same stimuli over development. Social maintaining is measured in terms of flattery or reputation management, and develops from age 3 to 18 on a variety of tasks (Martinsson, Nordblom, Rützler, & Sutter, 2011; Talwar et al., 2007).

Social seeking – expending effort to engage in social interactions - is the least explored component of social motivation. I will focus only on this component of social motivation. Some researchers have explored changes in brain activation in relation to rewards as a measure of social motivation (Kohls, Chevallier, Troiani, & Schultz, 2012; Pfeiffer et al., 2014). Hoogendam, Kahn, Hillegers, van Buuren, and Vink (2013) used fMRI with forty two 10-25 year old participants to evaluate brain activation for two elements of social motivation: reward anticipation and reward outcome. They reported that while brain activation for reward anticipation seems to increase with age, activation related to reward outcome seems to decline with age. Though neuroimaging can help

us to understand the underlying brain mechanisms of behaviour but due to both cost and practicalities, it is not suitable to be used with younger age groups and with individuals having different clinical conditions.

Other attempts to measure social seeking have focused on behavioural methods where participants can choose who to gamble with (Shore & Heerey, 2011) or choose whether to see a social or non-social movie (Dubey et al., 2015). These tasks show that typical adults prefer social stimuli over non-social stimuli even when it comes at the cost of some monetary loss or higher effort. An alternative behavioural task is the social incentive delay (SID) tasks (Cox et al., 2015; Flores et al., 2015; Kohls, Perino, et al., 2013). In this task, participants are cued to the reward they will receive for a fast keypress. They then have the chance to hit a key on seeing a target, and the speed of response is taken as measure of how much they want the reward. Several studies have used this measure of social seeking with mixed results. The data from Flores et al's and Kohls et al's studies found that typical adults have faster reaction time for social incentive condition but Cox et al found that reaction time of the participants was fastest for the non-social (monetary) condition.

Overall, though current evidence suggests higher reward value for social stimuli in typical adults but none of the above mentioned behavioural studies explored if the motivation to seek social stimuli is same during adolescence or childhood. There is only one study by Demurie et al (2012) that explored the performance of children and adolescents between ages 8-16 years on SID task. They reported that though the typical children and adolescents gave higher subjective rating for social incentive on five point Likert scale measuring how motivating or satisfying the task was. Despite that the social reward had no greater influence on the reaction time of the participants than the

non-social incentives, suggesting no greater reward value for social stimuli in this group.

Due to very sparse literature evaluating social seeking in typical adolescent and children, data from the studies in which typical participants were used as the matched control for clinical condition e.g. autism spectrum disorders (ASD) can also be used to understand the reward value of social stimuli in this age group. The data from the typical adolescent participants of autism related social seeking studies show that on a subjective rating scale the adolescents express high reward value for social stimuli (Chevallier, Grèzes, et al., 2012), however on the behavioural measures either they show no difference in their preference for social stimuli than non-social (Damiano et al., 2015; Silva et al., 2015), or show higher preference for non-social stimuli (Ewing et al., 2013; Kohls et al., 2011). These findings are different from what is found in the typical adults.

Like the lack of studies evaluating social seeking in adolescents there is only one study evaluating social seeking in typical children (8-12 years) (Kohls et al., 2009). They used social and non-social incentive based go/no-go task to measure reward value of stimuli. They compared small sub-groups of children, subjected to different types of reward conditions i.e. social, monetary, mixed, and no reward. On each trial, participants were presented a cue that indicates whether they should press or not press the key on seeing the target. Participants' key responses were followed by the presentation of the anticipated reward and the reaction time for the correct responses was recorded to estimate motivation to seek the reward. Kohls et al found faster improvement in task performance in terms of lesser error for all reward conditions than no-reward condition, more specifically the improvement was highest for monetary

incentives group than social incentives. This suggests that unlike adults (as seen in previously discussed studies) typical children prefer non-social stimuli over the social.

In younger children, it is again helpful to look at the performance of the control group in autism studies. The data from these studies show mixed results. Deckers et al (2014) while comparing children with ASD and typical controls found that 7-12 year old typical children do not show any preference for social stimuli (images of faces) over non-social (images of landscape). While Stavropoulos and Carver (2014) testing 6-8 year old children with and without ASD on a social and non-social incentive task reported that typically developing children show higher reward value for social stimuli (faces) than non-social (arrow mark). Therefore, it is difficult to conclude if social stimuli have higher reward value during early years for typical children or if there might be any developmental changes in social seeking over age.

The present experiment addresses this question. As discussed in earlier chapters CAM paradigm reveals the intrinsic preference for social or non-social stimuli, without making demands on social or language skills. Therefore this paradigm can be used with a wide age range. Here the CAM paradigm was used to explore the developmental trajectory of social motivation in a large sample of more than 250 healthy participants between ages 4-20 years. I believe that understanding typical development of social motivation can provide an essential point of reference for understanding atypical social motivation.

5.3 Methods

5.3.1 Participants

For this experiment data from 153 children between ages 4-11 years was collected during the two summer scientist week (SSW) public engagement programme of University of Nottingham. A 100 of these participants were from SSW programme held in 2012 and 53 were from SSW 2013. In total there were 80 females and 73 males. All these participants were typically developing children. To have wider age-range of 4-20 years, the data of typical participants from previous experiments (chapter 2 and 4) and another experiment discussed in chapter 6 were added to the 153 data collected for this experiment.

Overall, this study used a collated data of 255 participants (4-20 years) who originally participated in five different experiments (see table 5.1 for details). Some of these experiments included comparison with ASD groups but only data from typical participants up to age 20 years is presented here. These participants came from the mixed socio-economic and cultural background. Participants aged 12-17 years were recruited by contacting the local schools. The adult participants aged 18-20 years were contacted through posters in the university. Sample size for each study was determined before data collection began. All available data for typical participants aged 4-20 years old was included in the present analysis.

Ethical approval for all the experiments was provided by the ethics committee in the School of Psychology, University of Nottingham. Written informed consent for study participation was obtained from all the participants above age 18 years. For participants below age 18 years written consent was obtained from the primary caretaker/parent.

Table 5.1: Participant characteristics

Experiment	Chapter	Number	Female : Male	Age in years (M, ±SD)
Experiment 1	2	30	18 : 12	18 - 20 yrs (18.60, ±0.72)
Experiment 3	4	40	4 : 36	11.04 – 16.02 yrs (13.71, ±1.13)
Experiment 4	5	100	52 : 48	4.05 - 11.11 yrs (8.61, ±1.69)
Experiment 4	5	53	28 : 25	4.0 - 11.03 yrs (5.66, ±0.47)
Experiment 5	6	32	20 : 12	18 - 20 yrs (18.78, ±0.71)
Total		255	122 : 133	4 - 20 years

5.3.2 Stimuli

Participants in this experiment were compared for their choice between: social (direct gaze) and object movies only. Details of the stimuli used in the experiments are presented at the beginning of chapter 2.

5.3.3. Choose-a-Movie (CAM) paradigm

Participants completed the CAM paradigm on a laptop computer running MATLAB and Cogent. The details of the CAM paradigm are given in chapter 2. Here two slightly different versions of the CAM paradigm were used to suit the

attention span and cognitive abilities of the participants. Version 1 was completed only by the participants in experiment 1 (adults). The simpler version 2 was completed by participant from all the other experiments.

Version 1: In this version participants completed 180 experimental choice trials: 60 trials gave a choice between social (direct gaze) movies and object movies, and these trials are analysed here because they closely match version 2 of the paradigm. The remaining 120 trials are reported elsewhere (Dubey et al., 2015). On each trial, two boxes with locks on them were presented on a computer screen. Participants could respond by pressing key Z to remove a lock from the left box, or key M to remove a lock from the right box. The study started with 21 associative learning and practice trials which were then followed by 180 experimental choice trials as detailed above. Within the 60 trials analysed here, 32 showed 3 locks on one box and 1 on the other; 8 showed 2 locks on one box with 1 on the other, 8 showed 3 locks on one box with 2 on the other, and 12 showed equal numbers of locks on each box.

Version 2: In this version participants only had the choice between social movies of a smiling adult making direct gaze and movies of objects. The same movies were used as version 1. The task started with 10 associative learning trials and 2 additional instruction trials, details of which are given in chapter 4. These trials were then followed by 60 experimental choice trials. Responses were made by touching either the left box or the right box on a touch-screen laptop. Within the 60 trials, 24 trials had 3 locks on one box and 1 on the other; 12 trials had 2 locks on one box and 1 on the other, and 12 trials had 3 locks

on one box and 2 on the other; 12 trials had equal numbers of locks on each box.

5.3.4 Procedure

Adult participants in experiments 1 and 5 were tested in a quiet room on a university campus. Children in experiment 3 were tested in a quiet room in their own school. Both these cohorts received an appropriate inconvenience allowance after the study was complete. Children in experiment 4 were tested in a quiet space as part of the Nottingham Summer Scientists week event and received small goody bags at the end of the session. To ensure that younger participants made choices based on the learnt association these participants (experiment 4, age group between 4-11 years) were shown 6 additional trials in which they were asked to recall the learnt association between cue box and stimuli. Only participants who could recall the association correctly for 3 or more trials were included in the final data. Adult/adolescent participants (experiment 1, 3, and 5) were provided with verbal instructions and then completed the associative learning and practice trials. They were then able to continue with the experimental trials at their own pace without further assistance. Child participants (experiment 4) were verbally instructed of what they needed to do and completed the instruction and associative learning trials in the same way. The experimenter remained at the same desk as the child participants throughout the task, to encourage them to complete the experimental trials.

5.4 Data Analyses

The data collected from each participant includes an individual's age and gender, together with the choice they made on each trial. Two age-related predictors were calculated: zAge – zero-meaned participant age in years, which is the raw ages with the sample mean subtracted so that the whole population has a mean age of zero; $zAge^2$ – the same value squared. These allow for the construction of linear and quadratic models of how age relates to social motivation. The primary analysis done was a *logistic regression*, where a mixed-level logistic regression model including all trials and all participants was constructed. It tested how the choice to open (or ignore) the box on the left for each trial could be predicted based on the following factors: *Effort* - the relative number of locks on the left box compared to the right (-2, -1, 0, 1, 2); *Stimulus* - the type of stimulus on the left (social or non-social); *zAge* – zero meaned age as above; $zAge^2$; and gender. This was a mixed-level model using a logistic link function with participant ID as a between-subjects factor. Test for main effects of all the predictors and also for interactions of *Effort by Stimuli*; *Effort-by- zAge*; *Effort-by-*$zAge^2$*; Stimuli-by-zAge, Stimuli-by-*$zAge^2$*; Effort-by-Stimuli-by-zAge, and Effort-by-Stimuli-by-*$zAge^2$ were run. Results are reported in terms of the Wald statistic.

To visualise the results, the data was examined in two other ways. First, the data was split into the youngest third (4-7 years), middle third (8-13 years) and oldest third (14-20 years) of participants and plotted against the choices made by each subgroup. Second, a *basic preference analysis* was performed, where all the different levels of effort (which were balanced over trials) were collapsed and the percentage of trials on which a participant chose social

movies over object movies was calculated. This provided a crude quantification of social motivation in each participant and allowed to plot the basic preference against age for all individuals. zAge or $zAge^2$ were tested to explore if they could predict this basic social preference.

5.5 Results

5.5.1 Logistic regression

The results suggest that overall choices were significantly influenced by the effort (Wald $\chi^2 = 41.04$, $p < .0001$) whereas stimuli and gender were not the significant predictors (table 5.2). More importantly, there were significant interactions between age and other factors. The choice of items could reliably be predicted by the interaction of effort and zAge (Wald $\chi^2 = 31.07$, $p < .0001$), interaction of stimuli and zAge (Wald $\chi^2 = 7.00$, $p = .008$), and interaction of stimuli by $zAge^2$ (Wald $\chi^2 = 11.35$, $p = .001$).

Table 5.2: Logistic regression models for choice

Variable	Wald χ^2	P value
Effort	41.044	<.0001
Stimuli	.518	.472
Gender	.042	.838
zAge	.087	.768
$zAge^2$	.513	.474
Effort X Stimuli	7.053	.133
Effort X zAge	31.072	<.0001
Effort X $zAge^2$	6.479	.166
Stimuli X zAge	7.000	.008
Stimuli X $zAge^2$	11.345	.001
Effort X Stimuli X zAge	5.740	.219
Effort X Stimuli X $zAge^2$	2.239	.692

To aid interpretation of these results, the data was split into three age groups as described in the data analysis section. Choice behaviour for each age group was plotted in the lower part of figure 5.1. These plots show the mean number of trials where a participant chose the box on the left, dependent on whether that box contained a social movie (green line) or object movie (blue line), and on the relative number of locks on the left-hand box (x axis). The oldest participants (figure 5.1d) showed a typical pattern of choice behaviour, with a preference for social stimuli indicated by the green line lying above the blue line, and a preference for making less effort indicated by the steep slope

of the lines. This pattern is different in the preadolescents (8-13 year olds, figure 5.1c), who showed no major difference between social and non-social stimuli (blue and green lines cross, and nearly overlap) and a noticeable but weaker effect of effort. The youngest group (4-7 year olds, figure 5.1b) preferred the social movies for all levels of effort, and were only weakly sensitive to the effort manipulation. Overall, these plots illustrate the interactions with age found in the statistical analysis – effort has a stronger impact on older participants than younger participants, and a preference for social movies is seen in the youngest and oldest groups but not in the pre-adolescent group.

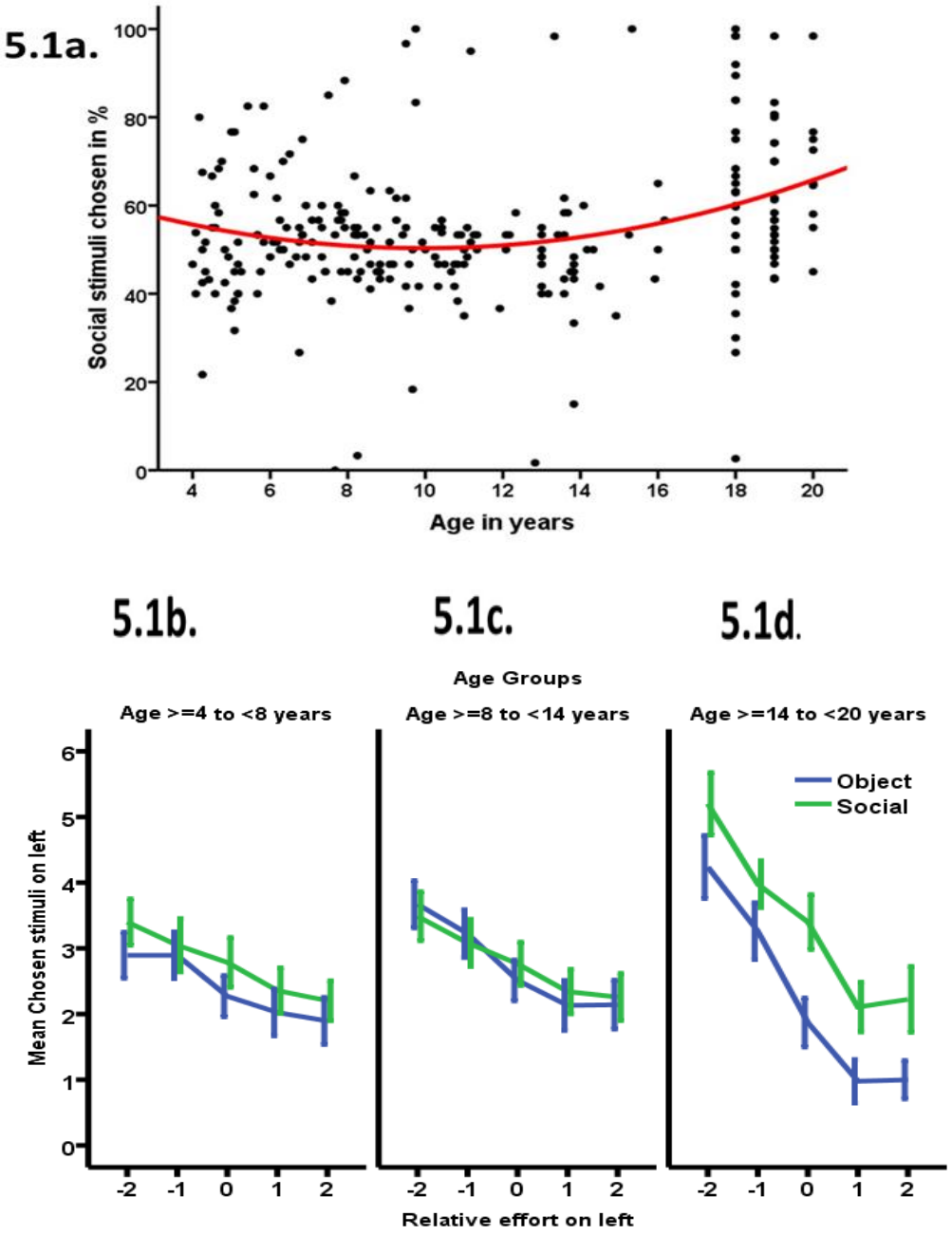

Figure 5.1: 5.1a) Preference for social stimuli in all participants aged 4-20 years. The red line shows the fit of the quadratic model. Plots **5.1b, 5.1c, 5.1d** shows mean number of trials (max=6) where participants chose the left box for a particular level of effort (x axis shows the relative effort level on the left side i.e. number of locks on left subtracted from number of locks on right).

The green line shows trials where the movie on the left was a social movie and blue line shows trials where the movie on the left was an object movie. Participants are split by age as indicated.

5.5.2 Basic preference analysis

An alternative visualisation of the data (figure 5.1a), shows that social preference (mean preference collapsed over the effort conditions) is high in the youngest children in the sample and in the adults, but dips around 11 years of age. A quadratic regression with predictors zAge and $zAge^2$ was able to reliably predict the preference for social stimuli ($R^2 = .080$, $F(2, 252) = 10.97$, $p < .0001$) – parameter estimates are given in table 5.3. This reinforces the primary result and shows that young children and adults have a stronger preference for the social stimuli compared to preadolescents.

Table 5.3: Quadratic regression model for social preference and age

Variable	***B***	**SE *B***	***B***	***t***	***sig.***
Age	-3.020	1.204	-.931	-2.509	.013
Age^2	.152	.049	1.157	3.119	.002

5.6 Discussion

This study describes the developmental trend for the social seeking component of social motivation from 4-20 years of age, measured using the CAM paradigm. Results suggest that all participants were influenced by the effort required on trials, and the preference for low effort increased with age.

Young children and adults preferred movies of people rather than objects but this social preference was not present in the preadolescents (age 8-13 years). In the next section I will discuss what these results means for understanding typical and atypical social functioning and why it is important to have an objective tool to measure social motivation.

This data demonstrate a surprising reduction in the motivation to view social stimuli in typical preadolescents. There are two possible explanations for this result. These findings could be explained by a genuine, global change in the motivation to interact as children develop, or by an initiation of narrowing of social interest in adolescence.

A global change in social motivation in preadolescence is compatible with the idea that social anxiety increases during this period (Ollendick, King, & Frary, 1989). However, it is not clear if such changes apply to all the preadolescents. If they genuinely undergo changes in their social motivation, then the 'normal standards' of evaluation of social motivation during this age need to be readjusted. This period is also marked by substantial brain changes. The structural development of the brain areas involved in social cognition (Mills, Lalonde, Clasen, Giedd, & Blakemore, 2014). Significant change in hormones and/or changes in environmental exposure during this age, both can be considered as potential triggers for such developmental dip in social cognitive skills during adolescence (Blakemore, 2008).

However, it is also possible that the observed dip in social motivation might reflect a narrowing of social interest rather than a global decline. The stimuli in the social movies used in this experiment depicted smiling adults mostly between 20-30 years of age. The data show that young children and adults find these movies engaging and motivating, but the preadolescents do

not. It is possible that young children are motivated to attend to movies of adults because adults can provide food, safety and opportunities to learn. As preadolescents require less direct adult support, they may look more to their peer group for social interaction. Perhaps therefore they have a more narrow social preference for their own age group (rather than all adults) so they show a reduced motivation towards viewing adults. In adulthood, this preference may not reverse, but rather the adult participants see the actors in the movies (age 20-25) as peers and are motivated to engage with them. This is consistent with previous studies showing that preadolescents may focus more on the opinion of their peer group while risk assessment of everyday situations than the opinion of adults (Knoll, Magis-Weinberg, Speekenbrink, & Blakemore, 2015), also preadolescents make more errors when they are being observed by their peer group than by adult experimenter (Wolf, Bazargani, Kilford, Dumontheil, & Blakemore, 2015).

This data also relate to previous studies showing non-monotonic dips in face recognition (Carey et al., 1980) and emotion recognition (McGivern et al., 2002; Ross et al., 2012) in adolescents, with an own-age bias in preadolescents (Hills & Lewis, 2011; Scherf, Behrmann, & Dahl, 2012) but not three year olds (Macchi Cassia, Pisacane, & Gava, 2012). This further suggests that motivational changes driving preadolescents to associate with and attend to their peers could be an important factor influencing their social functioning.

5.6.1 Clinical relevance

As it has been demonstrated in the current experiment, typical development may not always follow a linear progression, this is important to consider because in most of the clinical settings disruption in social functioning

is evaluated by comparing the reports of social functioning of a patient with "typical social behaviour". Furthermore, parental or informant reports are known to have several inconsistencies and biases (Achenbach, McConaughy, & Howell, 1987; De Los Reyes & Kazdin, 2005). Therefore it is important for clinicians to have a tool that can aid their understanding of current social motivation of the person.

It is rare to have a task that can be applied in the same way across a wide range of ages and abilities, but CAM fulfils this criteria. In the future it will be intriguing to see if CAM can be used in clinical populations to explore the developmental trajectory of social motivation. Though at the present no strong claims can be made yet about the clinical utility of this task, but it might be a valuable tool in research into clinical disorders, to quantify individual differences in social motivation and track responses to treatments.

5.7 Conclusion

The present experiment shows that changes in the motivation to seek social stimuli can be measured across 4-20 year age range, and that preference for viewing social movies of adults dips around 11-12 years. These data demonstrate the importance of measuring and understanding changes in motivation and social behaviour across a wide developmental age range, in order to improve our understanding of both typical and atypical social development.

CHAPTER 6: A COMPARISON OF TWO DIFFERENT MEASURE OF SOCIAL MOTIVATION

6.1 Abstract

The motivation to engage and interact with others can be considered a fundamental part of human behaviour, and variability in social motivation between individuals has been linked to some clinical conditions including autism spectrum disorders (ASD). However, it is not easy to define and measure social motivation. Here two different methods: Choose-a-Movie (CAM) and Approach-Avoidance (AA), which can quantify individual differences in this social seeking component of social motivation, are examined. In the CAM paradigm, participants make trade-offs between the number of keypresses required and viewing of social or non-social movies. In AA task participants make effortful keypresses to see or avoid images of people, everyday objects, and disgusting things. Forty seven typical under-graduate students were tested on these tools, results on the CAM paradigm showed clear evidence of a preference for social movies and a relationship between choice behaviour and autistic traits. In contrast, the same group showed only a weak preference for social images on AA task, and the social preference on this task was not related to autistic traits of the participants. These results suggest that the CAM paradigm provides a sensitive measure of social seeking behaviour than the AA task. Here I discuss

the implications of this finding and how social motivation can be better studied in the future.

6.2 Introduction

Motivation is an internal drive to perform particular behaviour or attain particular goals. It is a complex series of psychological events involving 1) learning association between action and consequence, 2) awareness or reactivation of anticipation of positive consequences in relation to the action, 3) perception of the situation and readiness to take action (Berridge, 2004). Perhaps same principles can be expanded to define social motivation, which is describe as "*a set of psychological dispositions and biological mechanisms biasing the individual to preferentially orient to the social world (social orienting), to seek and take pleasure in social interactions (social reward), and to work to foster and maintain social bonds (social maintaining)*"(Chevallier, Kohls, et al., 2012). As discussed earlier this research focus only on the 'social seeking' component of social motivation and because it is primarily an internal experience, it is not easy to measure social seeking objectively without using questionnaires or self-report. However, language based tools are of limited use to measure social seeking in younger children, people with limited cognitive and social abilities such as ASD. Therefore researchers use behavioural paradigms instead. Though researchers have used a variety of behavioural tools (discussed in detail in chapter 2) to estimate social seeking in typical and ASD populations, these tasks have important methodological differences. As a result these various approaches may be conceptualising and exploring social seeking differently.

The frequently used approach-avoidance - AA task (Aharon et al., 2001) is based on the idea that people approach positive stimuli and avoid negative stimuli. In this kind of task participants are presented with a stimulus on a computer screen and their tendency to approach or avoid it is recorded to estimate their motivation to seek out the image. In one version of this task, participants are presented with social images and are informed that they can change the duration of image presentation by making effortful key presses (Aharon et al., 2001). To make the key presses harder and effortful, sometimes researchers use a combination of difficult key presses such as pressing keys 'z' and 'm' in sequence, using the same finger (Aharon et al., 2001; Ewing et al., 2013). This kind of paradigm was used by Hayden et al (2007) to measure the motivation to look at attractive and non-attractive images of people in typical adults. In another type of AA task, participants see social images on the screen that can be increased in size by pulling a joystick (approach) or decreased in size by pushing the joystick (avoidance). The reaction time to perform an the approach or avoidance action is taken as the measure of "seeking" for that image (Enter et al., 2014; Rinck & Becker, 2007). Importantly, in both versions of the AA task the stimulus under investigation is visually present to the participants when they make their decision to either approach or avoid the stimulus.

The other kind of tasks used to measure social seeking are: The social incentive delay task (SID) (Spreckelmeyer et al., 2009), choice task (Watson et al., 2015), and CAM paradigm (Dubey et al., 2015). These tasks are based on the assumption that motivation is a product of a learnt association between a cue and the stimuli. All of these tasks present a cue to the participant about the possible stimuli they could view and participants make a behavioural response

based on the association cue. Therefore in these tasks participants make their decision to view a particular stimulus prior to their viewing it. Thus, anticipation of reward and its influence on their behaviour is recoded to estimate their motivation to get the target stimulus. In a typical SID task, on each trial, participants see a cue indicating strength of reward (e.g. a circle with one line would predict small smile and a circle with two lines would predict a big smile) that will be presented at the end of the trials and the participants wait for a "GO" signal to make a key-press response. They are instructed to respond to the "GO" signal as fast as possible. The reaction time for responding to the "GO" signal is taken as a measure of the participant's motivation to see the anticipated reward (Spreckelmeyer et al., 2009).

The CAM paradigm is similar to the SID task in terms that decisions are made to view a stimulus prior to viewing it, however it differs in an important way. Unlike SID, CAM paradigm is based on response to forced choice, in which participants are presented with the choice between two stimuli (e.g. social and non-social) with different levels of effort (key –presses required to open each). While in the SID task participants cannot choose the nature or strength of reward on CAM paradigm participants choose to view any one stimulus by making the required effort. It is assumed that in choosing which stimulus to view, participants make a trade-off between the intrinsic value of each item and the effort (number of keypresses) required to view it.

The choice task by Watson et al (2015) is very similar to CAM paradigm in conceptualising as well as presenting the stimuli. In Watson et al's choice task the participant is presented with a choice between either looking at a scrambled image with fixed monetary reward or to look at the image from the target stimuli (e.g. faces) with variable amount of monetary reward. The

motivation to seek the target stimulus is hence estimated as the monetary loss bore by the person to look at it. This is similar to the idea of making higher or lower effort in the CAM paradigm to look at the preferred stimuli.

As the CAM paradigm overcomes the limitations of SID and is very similar to the choice task of Watson et al, I chose it to compare against the AA paradigm which uses a different methodological approach to test social seeking. In the next section I will discuss some of the findings from the studies using AA and CAM paradigm to test the reduced social motivation theory of ASD.

Silva et al (2015) used AA task with adolescents with and without ASD. They used images of cartoons, which they believe have higher incentive salience for people with ASD and images of real people. The participants used a joystick to pull or push the stimuli. Results from this study showed that participants with ASD approached positive cartoon images and avoided positive real social images more than the typical controls. This shows evidence of social avoidance in people with ASD. In a different study, Ewing et al (2013) used an AA task to measure the approach for social stimuli (faces) in comparison to non-social stimuli (cars) in adolescent participants with and without ASD. The results showed that adolescents with autism and matched controls invested same effort to see all social/non-social images, and both the groups spent significantly more effort to see images of cars than faces. This study might indicate that higher approach for non-social stimuli might not be specific to ASD in this age group. In a different study Deckers et al (2014) used a face-turn approach avoidance task along with the “wish for social interaction scale” to measure social seeking in ASD. Results showed that although participants with ASD expressed a reduced desire to have social interaction on a subjective rating

scale they approached both social and non-social stimuli equally on the AA task. These findings indicate that there might be a dissociation between social seeking, as evaluated on an explicit measure and AA task, in people with ASD. Overall, the studies using AA task to test reduced social motivation theory of ASD show inconsistent findings making it difficult to support or reject the theory.

The recently developed CAM paradigm was also used to measure social seeking in typical adults. The findings from this paradigm show that typical adults prefer social stimuli over non-social and trade-off their stimuli preference for the effort (see chapter 2). The major findings of this study were replicated in the second experiment in which CAM paradigm was used to compare adults with and without ASD. In this experiment, while adults with ASD prefer to look at the non-social images than social, adults without ASD preferred looking at the social (direct gaze) stimuli (see chapter 3). Like experiment 1, in this experiment as well, the participants (irrespective of their clinical group) trade-off their stimuli preference for the effort involved in the task (Dubey et al., 2015). The findings of people with ASD being more willing to make higher effort to look at the non-social image than social was also replicated in the third experiment using CAM paradigm with adolescents with ASD (see chapter 4). Therefore, unlike AA tasks the findings from the CAM paradigm have been consistent over different experiments and age groups of people with ASD.

The aim of this chapter is to compare two tasks: AA and CAM, in the same group of typical adults to measure social motivation in relation to autistic traits. It is believed that this comparison will help in determining if these tasks measure the same construct and if either of these is a more sensitive measure of individual difference in social seeking which might relate to the presence of autistic traits.

6.3 Method

6.3.1 Participants

Participants were recruited through the School of Psychology's research participation scheme and posters in the university campus. To explore the relationship between social seeking on the two tasks and autistic traits I aimed to recruit participants with a wide range of autistic traits. Initially 38 participants contacted the investigator to participate in the study and they were all included in the study. Later, part of the study was also advertised for students to do only the online measure of the adult autism quotient scale (AQ) (Baron-Cohen et al., 2001). More than 400 undergraduate students completed the online version of the scale. From these participants, all those who scored either below 7 or above 25 score were invited to take part in the present study. In response, the investigator was contacted by only nine more participants from this group. All of these nine participants were included in the study. Overall, 47 undergraduate students (24 females) between ages 18-41 years (M = 20.06 years, SD = ±4.45) took part in this study. Note that all recruitment was based only on AQ scores. These participants received course credit or an inconvenience allowance for their participation. They were informed about the larger aim of the project but were not aware of the specific aim of the study till they finished the experiments.

The initial design of the study was aimed to measure social seeking using two different tools and then to explore the effect of a 'social exclusion' manipulation using cyberball (Williams, Yeager, Cheung, & Choi, 2012) on social seeking measured by CAM. Unfortunately, very few participants believed the cyberball manipulation. Thus, the present chapter focuses only on the first

aim i.e. comparing the two methods, and therefore I here report only the baseline blocks (60 trials) of the CAM (before the cyberball manipulation) and the AA tasks.

6.3.2 Tools

***6.3.2.1 Approach-Avoidance (AA) task*:** The task was presented using MATLAB with Cogent toolbox on 12 x 6.5 inch screen of a Samsung Ultrabook. Sixty images used in the study were taken from an internet search. They were from three major categories: 20 images of adults (10 females: 10 males) with direct gaze and a social smile; 20 images of regular household objects; 20 images of disgusting things such as animal faeces, dirty toilet, dead animal etc. (see figure 6.2). The aim of using aversive images was to provide a strong contrast to the social/non-social images and ensure participants were attentive to the images being presented. All the images were free of copyright restrictions and could be used for personal/academic purposes. To control the influence of low level features such as bright colours, images were transformed to black and white format. The background of the images was kept unaltered to make sure they look natural and do not evoke any special interest due to uniqueness.

Figure 6.1: Example of social, objects, and aversive images used in the AA task.

There were two phases of the task: the approach phase and the avoidance phase (figure 6.2). For the approach phase participants were given the following instructions "*You will see some pictures. Each picture will initially remain on screen less than 1 second. After which it will disappear and a blank screen will be shown for the next 6 seconds. During these 6 seconds you can either look at the blank screen or bring the picture back by pressing key H. Please keep pressing key H if you want to look at the picture longer. The total viewing duration cannot be increased beyond 6 seconds.*"

For the avoidance phase following instructions were presented "*You will see some pictures. Each picture will remain on screen for 6 seconds. You can REMOVE the picture anytime by pressing the key H. If you do not want the picture to return, you must keep pressing key H."* Participants were also informed that each trial duration is fixed to a total duration of 6 seconds and it does not increase or decrease with their key-presses also that they must look at the screen all the time even if they choose not to bring back/avoid (i.e. the screen is blank) the image.

Participants completed 60 trials of the approach task with all 60 images in a pseudorandom order, and also 60 trials of the avoidance task with the same

60 images in a pseudorandom order. Presentation of the two phases: approach and avoidance, was randomised between participants. For both phases, the responses were recorded in terms of milliseconds of viewing time.

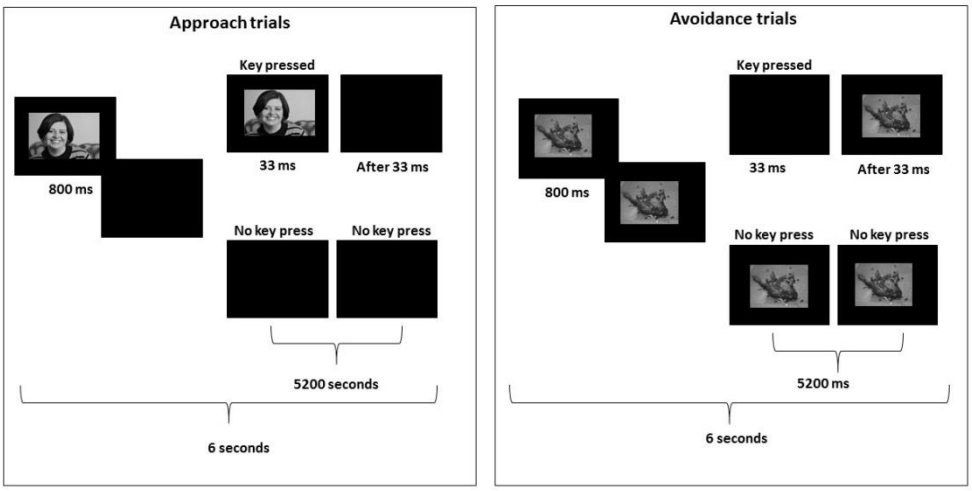

Figure 6.2: Trial structure for approach –avoidance task (each keypress shows/removes the image for 1 screen refresh which is 33 msec)

6.3.2.2 Choose-a-Movie (CAM) paradigm: The details of this paradigm are given in the previous chapters 4 and 5. Here the touch screen version of the paradigm with two set of stimuli (direct gaze v objects) was used. There were 10 associative learning and 60 experimental trials of choosing between the two boxes. The boxes could have 1 to 3 locks on each of them. Within these 60 trials, 24 trials presented 1 lock on one box and 3 locks on the other box, 12 trials presented 1 lock on one box and 2 on the other, 12 trials presented 2 locks on one box and 3 on the other, and 12 trials presented an equal number of locks on both the boxes.

6.3.3 Procedure

The participants completed an online version of the AQ (English) and gave their consent to participate in the study. They were then invited to the lab where they completed the CAM and AA tasks. The presentation sequence of the two tasks was counterbalanced between participants to prevent the influence of order effects. For the CAM paradigm, participants completed 60 trials which were fully counterbalanced to measure preference for each of the two movie types. They then completed the cyberball manipulations and further blocks of the CAM paradigm (not reported here). For the AA task, they completed 60 trials of approach and 60 trials of avoidance in a counterbalanced order. Participants were debriefed about the specific aim of the experiment at the end of the session.

6.4 Results

6.4.1 Social motivation measured by Approach-Avoidance (AA) task

In the approach AA phase each key-press made the picture available for 33 milliseconds only. Hence to look at the picture longer participants needed to make very quick regular key-presses. More frequent key presses that ensured a longer exposure to the available image. The total duration (maximum 6 seconds) of viewing an image indicates the effort made by participant to look at it and therefore can be taken as an estimate of motivation to seek that stimulus.

Similarly in the avoidance phase each key press removed the picture from the screen for 33 milliseconds. The average duration of images from each

category being avoided was measured to indicate social avoidance, non-social avoidance and avoidance of aversive images. These results are presented below in figure 6.3.

A comparison was made for the average duration of both approach and avoidance of the three sets of stimuli for the participants who did the CAM paradigm first and AA task second and those who did AA task first and CAM second. The results showed no significant difference between the mean approach –avoidance duration of the two sets of participants for all categories except avoidance of aversive images (t (43) = -2.026, p = 0.049). This showed the participants who did CAM first and AA second had a mean avoidance duration of 1.83 seconds (SD=1.65) and for those who did AA first and CAM second mean avoidance duration for aversive stimuli was 2.82 seconds (SD=1.70). The aversive stimuli condition was presented as a control condition in this study and the focus of the discussion here is the approach or avoidance for social and non-social stimuli. Therefore, the active avoidance by more key presses on aversive condition confirm here that participants were attentive during the task and were most motivated to avoid aversive images but these results contribute little in the next sections.

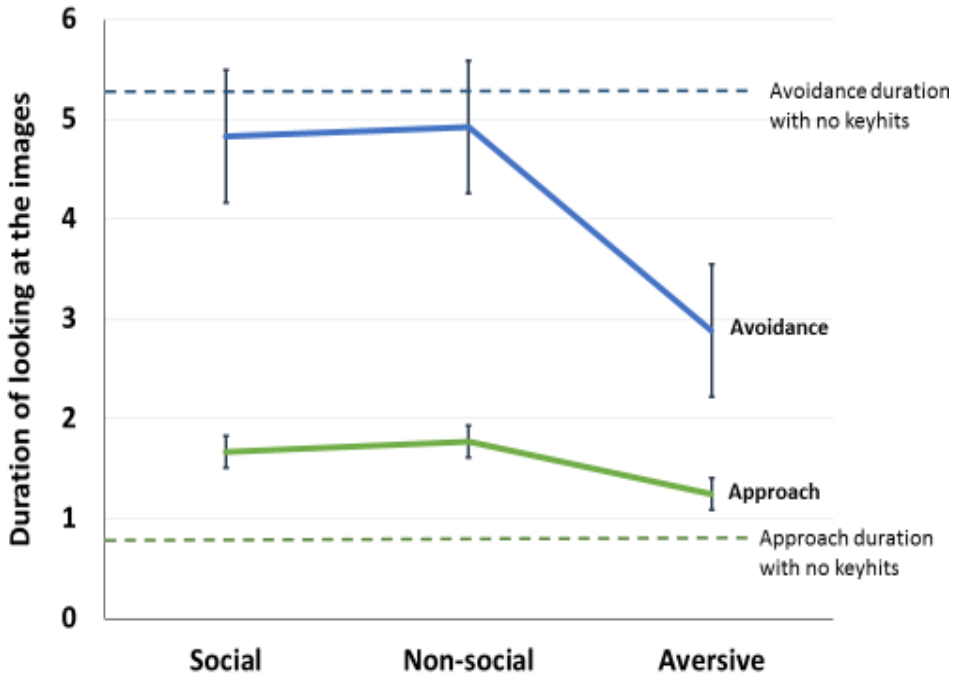

Figure 6.3: Mean duration (seconds) of looking at the three sets of images in approach and avoiding sets

As the figure suggests during the approach trials participants spent a mean duration of 1.67 (SD = 1.37) seconds looking at the social images, a mean duration of 1.77 (SD = 1.48) seconds looking at the non-social images and 1.25 (SD = 1.36) seconds looking at the aversive images. This shows a significant difference in the looking durations in the three sets of images F (2, 92) = 4.586, p=0.013*, ηp^2 = 0.091. The post-hoc comparisons between social vs aversive (p=0.086), non-social vs aversive (p=0.039) images show that participants spent significantly less time viewing aversive images. There was no significant difference between the approach duration for social vs non-social images (p=1.00). Though none of these differences would be significantly different if tested against the corrected p value (0.017) for multiple comparisons. For the

avoidance set, participants spent a mean duration of 4.83 (SD = 0.73) seconds looking at the social images, 4.92 (SD = 0.71) seconds looking at the non-social images, and 2.88 (SD = 1.73) seconds looking at the aversive images. Greenhouse-Geisser correction was applied to the analysis for comparison of mean duration of looking at three sets of image. The results suggest that there was a significant difference in the avoidance duration for the three sets of the stimuli F (1.11, 51.089) = 57.39, p<0.0001*, ηp2 = 0.555. The post-hoc comparisons show a significant difference in the duration of avoidance between social vs aversive images (p<0.0001), and non-social vs aversive images (p<0.0001), however there was no significant difference in the duration of avoidance between social v non-social images (p= 0.579).

6.4.2 Social motivation measured by Choose-a-Movie (CAM) paradigm

The CAM paradigm measures the preference for social stimuli over the non-social stimuli against different levels of effort. As it presents a binary choice in each trial, logistic regression analysis was used to estimate the choice behaviour of the participants. The results showed that participants were significantly influenced by the stimuli type (Wald χ^2 = 18.68, p < 0.0001) i.e. they clearly showed a preference for one set of stimuli over the other. Their choice was also influenced by the effort levels (Wald χ^2 = 51.07, p < 0.0001) i.e. they did not choose any one stimulus rigidly over different effort conditions but were careful to choose the low effort options. There was also a significant interaction between effort and stimuli (Wald χ^2 = 13.06, p < 0.011) and as figure 6.4 suggests participants preferred social stimuli on most of the effort levels but

the preference is more prominent when the effort difference between the choices was zero (i.e. both the stimuli were presented with same number of locks). This preference was also strong when the effort difference was +1 or -1 locks, but as the difference increased the preference for any specific stimuli fell down. This shows that participants made a careful trade-off between their social preference and required effort, which can be clearly quantified using CAM paradigm.

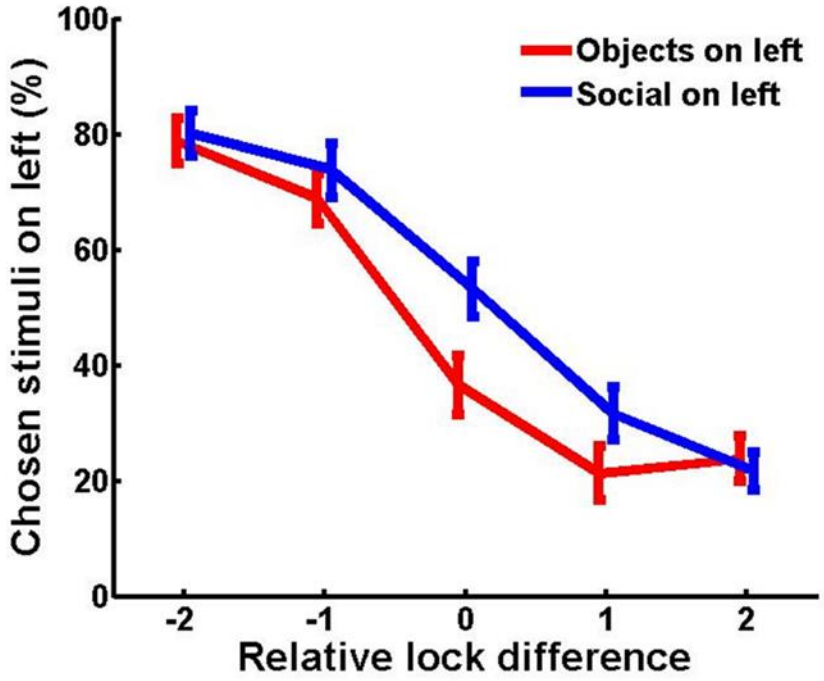

Figure 6.4: Preference for each stimulus (two coloured lines) over different levels of relative efforts (e.g. -2 on X axis represents 1 lock on left and 3 on right side)

6.4.3 AQ and social motivation on two tasks

Pearson correlation coefficient was used to explore the relation between social motivation as measured by the AA task (social seeking- duration of making effort to look at social images in the approach phase; social avoidance- duration of making effort to avoid looking at social images in the avoidance phase) and as measured by CAM paradigm (percentage of trials on which participants chose social over no-social stimuli). The results as presented below suggest that there was no significant correlation between the duration spent on seeking (r (45) = - .224, $p=0.130$) or avoiding (r (45) = - .205, $p=0.167$) social images and the AQ of participants on the AA task. On the other hand there was a strong negative correlation (r (45) = - .499, p <0.0001) between the AQ score and social seeking on the CAM paradigm (figure 6.5). There was no correlation between the social seeking on AA task and CAM paradigm, indicating perhaps these tasks may not be measuring the same construct.

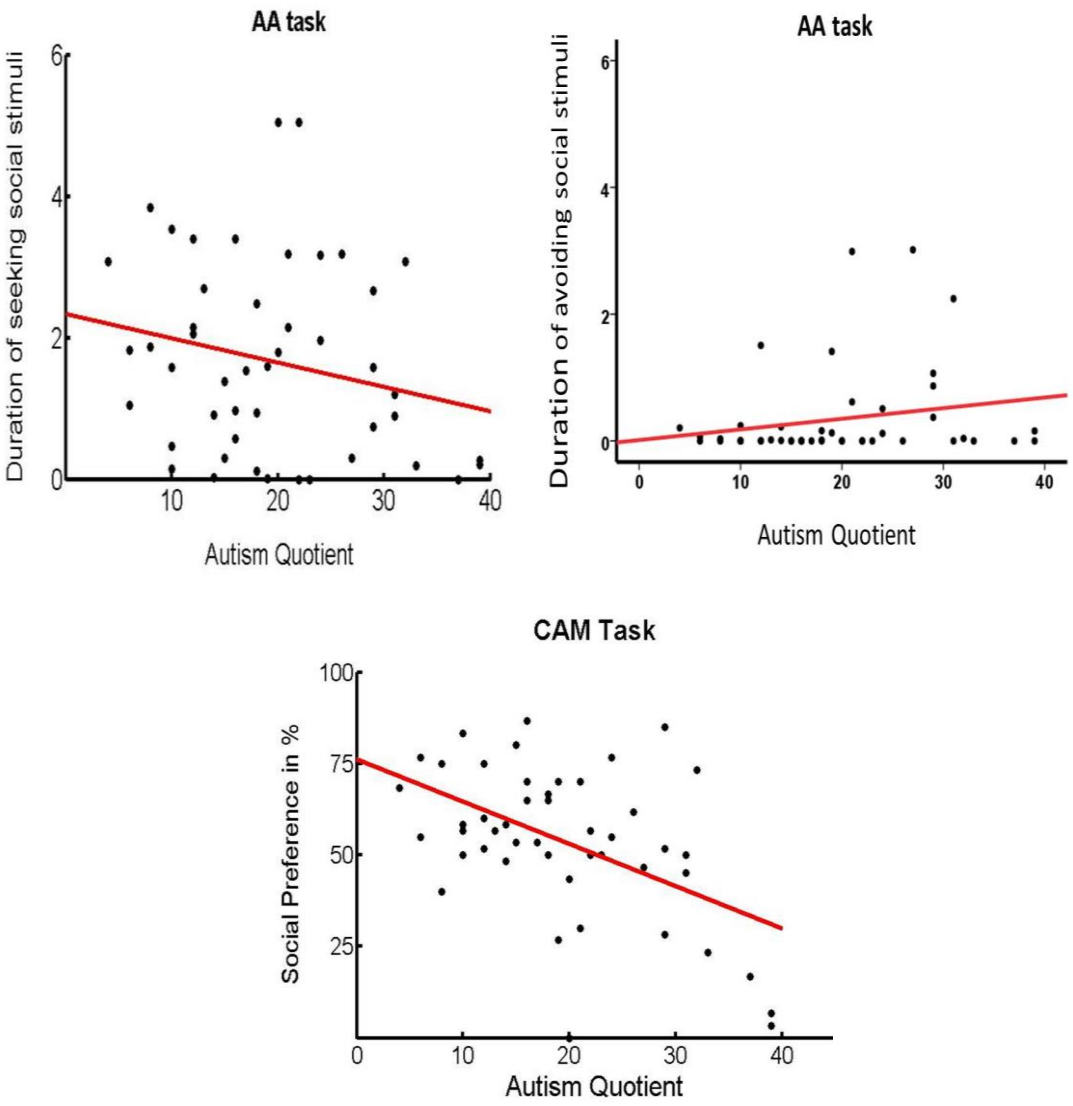

Figure 6.5: Correlation between autistic quotient and social preference: The figure on top left shows social seeking on AA task measured as average duration of looking at social stimuli on the approach phase. Figure on top right shows social avoidance on AA task measured as average duration of avoiding social stimuli on the avoidance phase. The figure in the bottom shows social seeking on the CAM paradigm measured as percentage of time participant chose social stimuli over non-social, irrespective of effort level.

6.5 Discussion

The aim of this study was to compare two different measures of social motivation in relation to autistic traits in typical adults. All the participants completed both a key-press based AA task and CAM paradigm. Participants avoided negative stimuli in the AA task but did not show a preference for social stimuli over non-social stimuli. The overall duration of viewing social images on this task was not related to the autistic traits of the participants. However, on the CAM paradigm when forced to make a choice between social and non-social stimuli, participants showed a clear preference for social stimuli which also correlated with their autistic traits. This replicates previous findings (Dubey et al., 2015) and demonstrates that the CAM paradigm is a sensitive and reliable measure of social seeking behaviour in relation to autistic features. In the next sections I discuss each of these tasks in detail.

6.5.1 The approach-avoidance (AA) task

The AA task is based on the premise that people approach the stimuli they are motivated to view. The results showed that the AA task is able to discriminate the preference between neutral and aversive stimuli, where the difference is very clear. However this task is unable to highlight any difference between social and non-social stimuli preferences, where a difference might be more subtle. There are several reasons AA might be less sensitive in identifying a preference for social or non-social stimuli. I will now discuss these possible reasons in detail.

On each trial the participant is presented only one stimulus on the screen and he/she is expected to press keys to approach or avoid it. Therefore

this task tries to measures the preference for each set of stimuli against looking at a blank screen (doing nothing). However, there are some limitations to this method. First, it has been suggested that 'doing nothing' is a negative experience for many people. People try to avoid 'doing nothing' by even engaging in non-rewarding activities (Wilson et al., 2014). Therefore the choice between looking at an image or 'doing nothing' in AA tasks might influence participants' behaviour in a different way than just the approach motivation. It might result in key pressing behaviour to avoid a negative experience of looking at a blank screen rather than seeking reward. Second, it is not clear if the choice between viewing an image and viewing a blank screen has much ecological validity. In real life situations, people generally have multiple options to choose from and their final choice is a result of a complex evaluation of the utility of each option against others. This regulates the preference for any stimuli in a complex manner, for example consider the condition in which a hungry person is presented with the choice between diluted juice and water. The person is likely to assign a high reward value to diluted juice in this condition. However, if the same choice is presented against slightly sweetened juice the person might assign a lower reward value to the diluted juice. In both the conditions the diluted juice is same but the presence of the alternative choice (water or sweetened juice) can alter its reward value. Therefore the less preferred stimulus can have high reward value until it is presented against a highly preferred stimulus (Zellner et al., 2006).

Another limitation of the AA task is that, it may be hard to separate effects of low-level stimulus features from more abstract concepts of what a person likes to approach or avoid. It is known that the responses elicited by looking at a stimuli might be influenced more by the low level features of the

stimuli than the learnt awareness of its pleasant properties (de Bordes et al., 2013; Itier et al., 2007). As an extreme example, a hypothetical participant who does not like pinkish/brownish colours might avoid all face stimuli due to a colour preference rather than a dislike for social images. In the present study, all images were converted to monochrome and attempted to visually match the images on clarity and complexity. Nevertheless it is hard to be sure if the responses made by the participant primarily reflect the motivation to engage with that set of stimuli or influence of some other visual features such as contrast or shapes.

To summarise, the AA task can provide a good measure of avoidance of negative images, but does not distinguish neutral from positive images therefore it might be a useful tool to measure threat or anxiety reaction rather than approach motivation.

6.5.2 The Choose-A-Movie (CAM) paradigm

The second task used in this study to measure social seeking is a forced choice CAM paradigm. This task evaluates the motivation to seek a stimulus against other stimulus while manipulating the effort levels. This data showed that participants preferred social stimuli over non-social stimuli in all the effort conditions. Furthermore, the autistic traits of the participants were highly correlated with the preference for social stimuli. Here I will discuss the factors that might make the CAM paradigm sensitive to relative reward value of the stimuli.

CAM paradigm presents two stimuli to choose from; hence it measures the relative reward value of the stimulus under investigation. This kind of reward

value of a stimulus may be more predictive of real life behaviour where choices are made in relation to each other. However, the CAM paradigm presents a choice between only two stimuli whereas in a real life situation people generally have more than two available options and they make a complex comparison of utility of all these choices before making their decision. It will be interesting to see if the preference for social stimuli as observed on CAM in this study will remain same if there are more choices than two.

Motivation is a complex phenomenon and it emerges from the awareness of response contingency. For example, previous experience of a pleasure contingent upon ingestion of sweet food would lead to activation of drive to get that food again. The CAM paradigm is based on associative-learning and activation of drive emerging from previous experience and anticipation of pleasure. The participants make the decision by looking at the cues (the patterns associated with two sets of stimuli). Hence they are less likely to be influenced by the low level features of the stimuli while making the decision. Thus, the CAM might be a more sensitive tool to measure seeking behaviour than AA tasks.

CAM paradigm uses short videos of stimuli such as a person making eye contact and smiling, or objects rotating. It is shown that the dynamic stimuli have higher ecological validity than the still images (Hanley et al., 2012). Therefore they are more likely to elicit typical behaviour of the participant than still images or line drawings. Perhaps it can be anticipated that the reward value of social interactions might have greater influence on behaviour of people when the stimuli are more lifelike than the still images and that might be the reason why we observed clearer preference for social stimuli on CAM paradigm than

AA task. Unfortunately due the very nature of the AA tasks it is not feasible to use video stimuli in them.

6.5.3 Task performance in relation to autistic traits

The comparison between the social preferences on two tasks in relation to autistic traits showed that on AA task participants' effort to look at the social images seem to have little association with their autistic traits, but on CAM paradigm this association is very strong. This difference might be attributed to two main features of these tasks. Firstly, as suggested by Sasson, Turner-Brown, Holtzclaw, Lam, and Bodfish, (2008) the preference for social stimuli in ASD is strongly influenced by the other stimuli competing for attention. People with ASD are more likely to explore social stimuli if they are presented against low autism interest objects than when they are presented with high autism interest objects such as trains. Therefore the social and non-social preference without any competing stimuli as measured in AA tasks might have little relation with the autistic traits of the person, while the preference for one over the other as measured in CAM might evoke a relative preference that is closely linked to the autistic traits of people.

The second reason for observing such a large difference in social preference of the same participants can be attributed to the stimuli used in these tasks. Comparison between stimuli with different levels of ecological validity such as static images, acted and posed social interactions and natural social interaction video clips showed that the atypicality of visual attention in ASD becomes more prominent as the ecological validity of the stimuli increases (Chevallier, Kohls, et al., 2015; Hanley et al., 2013). Though the within task

comparison between set of stimuli would not be influenced by this feature, the difference between the social preferences on two tasks in relation to autistic traits might be attributed to the ecological validity of the stimuli used in them.

6.6 Limitations

The literature shows different versions of AA tasks that are based on same principle but vary in the ways participants can make behavioural responses to them. The AA task used in the present study was based on the principles used in these tasks. Therefore it is close to most of the AA tasks used in the literature, at the same time the current task does not match any one of them exactly. The current task differs from others either in terms of keys chosen for response or the category of stimuli used etc. Another limitation of the study is the kind of stimuli used in the tasks. While images on AA tasks were downloaded from the internet and hence were not matched precisely for various factors such as style, background, colours etc., the stimuli used on CAM paradigm were originally developed by the author and were largely matched on the background and style. In future the still images extracted from the same videos that are used in the CAM paradigm might be used in the AA task to make a more precise comparison between two tasks.

6.8 Conclusion

This study indicates that though the AA task and CAM paradigm have both been designed to measure ‘social seeking’ the difference in their presentation of choice (absolute or relative) and type of stimuli (images vs

movies) might influence participants' behaviour significantly resulting in a difference in the findings obtained on them. The findings in relation to autistic traits suggest that the CAM paradigm might be more sensitive in identifying behavioural differences than the AA task. Therefore it can be suggested that the validity of the AA task might be improved by using more ecologically valid stimuli. The CAM paradigm might also be improved by presenting more than only two choices on each trial, which will mimic real life decision making more closely.

CHAPTER 7: GENERAL DISCUSSION

Social motivation is a broad concept that includes a wide variety of conscious and unconscious behaviour facilitating social interactions. These behaviours are: attention to the socially relevant cues from the environment, experience of reward from social interaction, and making effort to have immediate social interactions, as well as long term social affiliations. Social interactions are a vital component of healthy development and well-being. Difficulty in forming or having long term social interactions results in poor adjustment and a lower quality of life (Campisi, Folan, Diehl, Kable, & Rademeyer, 2015). This is also the reason why poor social adjustment is seen as one of the major diagnostic criteria for several clinical conditions (Kawachi & Berkman, 2001). ASD is one of such conditions, characterised by major difficulties in social interactions from a very early age. Dawson et al (1998) suggested that reduced motivation to engage with others might be one of the reasons underlying the failure of people with ASD to orient to social cues during their early years. This idea was further explored and presented as a comprehensive theory by Chevallier, Kohls, et al (2012), who proposed a wide definition of social motivation that not only included social orientation, but also social seeking and social maintenance. Rather than exploring each of these components, the current research focused on the social seeking aspect of theory. Therefore, the primary aim of this research was to explore if social seeking is reduced in ASD. Other than this the current research also explored questions about developmental changes in social seeking in typical people and

if the social seeking behaviour measured on CAM is same as social seeking behaviour measures on other frequently used tool of social seeking.

In chapter 1 of this thesis, I discussed the limitations of the existing cognitive theories, and emphasised the need to explore the social motivation theory to understand variability in the social difficulties in ASD. Through discussing the existing methods used to evaluate social motivation, the limitations of these become clearer. Therefore chapter 2 was aimed to develop a simple computer paradigm that could be used with people having ASD as well as typical controls. In chapter 2, at first an attempt was made to objectively define social seeking, drawing from definitions of motivation proposed by Berridge (2004). Secondly, the strategies that could be used in the new paradigm to overcome the previously observed limitations, such as using more ecologically valid stimuli and eliminating effects of low-level visual features were discussed. Finally, a novel Choose-a-Movie (CAM) paradigm was developed and used with typical university students in relation to their autistic traits. The findings from this study suggested that CAM paradigm could efficiently measure social seeking and could also sensitively identify the difference in social preference in relation to autistic traits.

With the development of this new paradigm, the theory of reduced social motivation could be objectively tested. Hence, a group of adults with ASD and a group of matched control participants were tested on CAM. This study was presented in chapter 3 of this thesis, in which the performance of two groups on the CAM paradigm was compared. The results from this study suggest that both the groups were influenced by the effort involved in the task, i.e. they traded-off their preference for stimuli with the effort, however effort interacted with their preference for stimuli. While typical adults preferred to look at social

stimuli and made higher amount of effort for them, adults with ASD preferred non-social stimuli and made more efforts to look at these stimuli. The opposite nature of social preference between the two groups supports the reduced social motivation theory of ASD. These results also suggest that the CAM could be used to measure social motivation in people with and without ASD. However, this study is limited in that it was only conducted with high functioning adults with ASD, therefore these results could not be generalised to the larger ASD spectrum who have learning difficulties.

To overcome this, in the next experiment (chapter 4) the CAM paradigm was adapted to meet the needs of participants with limited cognitive abilities and a younger group of ASD participants was tested using this. Unlike its previous version, there was only one choice condition (direct gaze social stimuli vs non-social stimuli) in the adapted version. This reduced the task duration from 30 minutes to 18 minutes. Further, to make it more interesting for younger participants the task was adapted to be used on a touch screen laptop. This also made the task more mobile as the laptop could be used at schools and set-ups familiar to participants. Lastly, to ensure that the participants remember the association between the stimuli and the cue (coloured boxes), some additional instruction trials were added in the beginning of the paradigm. The adjusted CAM paradigm was then used with 40 adolescents with ASD and 40 matched controls. This experiment partially replicated the findings from the second experiment, like the adults with ASD, the adolescents with ASD also preferred non-social stimuli over social and they traded-off their stimuli preference for effort. However, the matched typical adolescent participants did not show any preference for stimuli type. They were primarily influenced by the effort involved in the task.

Based on the findings of chapter 2, 3, and 4 it can be summarised that people with the diagnosis of ASD and those with higher autistic traits prefer to choose non-social stimuli over social. This preference is not influenced by the low level features of the stimuli but emerges from the previous experience of reward, association between cue and available stimuli, and behavioural action to seek (make more effort) the preferred stimuli. As all three studies discussed in chapter 2, 3, and 4 replicate the results for ASD participants or in relation to autistic traits. Therefore, it can be concluded that people with ASD have reduced social motivation. This conclusion raises further questions about the theory of reduced social motivation in ASD, which are discussed in the later subsections of this chapter.

The above discussed experiments though support the theory of reduced social motivation in ASD, at the same time raised questions about the developmental changes in the social motivation in the typically developing people. This question was explored in chapter 5, in which 153 participants between ages 4-11 years were tested on the CAM paradigm. This data was added to the pre-existing data of the typical participants between ages 11-20 years who completed CAM paradigm in experiment 1, 3 and 6. This resulted in a large data pool of 255 participants between ages 4-20 years. The results from this data showed that young children and adults preferred to look at social stimuli over non-social but pre-adolescents (11-12 years) did not show same preference. This data suggest that either typical people undergo a general decline in their social seeking behaviour during preadolescence or they might experience narrowing of social interest resulting in decreased tendency to seek social contact with adults. These results highlight a strong need to have a better developmental understating of social seeking in typical people, who represent

the normative behaviour for investigating any difference in social motivation in the clinical population such as ASD.

Finally, in the last experiment of this research the newly developed CAM paradigm was compared with the frequently used tool for social seeking- Approach-Avoidance (AA) task. Although these two tools claim to measure same behaviour (i.e. social seeking), they differ from each other on various aspects such as presentation of stimuli, recording of response behaviour, and the ecological validity of the stimuli. As these tools claim to measure the same construct, it was expected that participants' social seeking behaviour would be same on both. Forty seven typical adults completed these two tools along with a measure of their autistic traits. The results showed that participants had a strong preference for social stimuli over non-social on the CAM task but they did not show same preference on AA task. Furthermore the social seeking behaviour on CAM was a strong predictor of participants' autistic traits but neither approach nor avoidance of social stimuli on AA task could reliably predict the autistic traits of the participants. These findings raise a question if the tools claiming to measure same construct of social seeking evaluate the same behaviours.

In the next sections I will discuss the important questions raised during this research:

1) Does social seeking change with the development?
2) Do tools claiming to measure social motivation target same behaviour?
3) Can reduced social seeking be seen as: increased non-social preference rather than low social preference?

4) Is reduced social preference in ASD a generalised concept or is it limited to direct eye-gaze conditions only?
5) Is reduced social seeking in ASD a result of low reward value of social interaction or aversion from them?
6) Reduced social motivation: A cause or a consequence

7.1 Development and social seeking

It is known that development can have significant influence on the neurocognitive abilities of people (Crone, Jennings, & Van der Molen, 2004; Huizinga, Dolan, & van der Molen, 2006; Lee, Booth, & Chou, 2015; van den Bos, Cohen, Kahnt, & Crone, 2012) especially during adolescence (Giedd et al., 1999; Weil et al., 2013). These changes can be either progressive such as increase in the ability to understand what other people are thinking or feeling i.e. theory of mind (Dumontheil, 2015; Sebastian, 2015), emotional attention (Vetter, Pilhatsch, Weigelt, Ripke, & Smolka, 2015), or have a non-linear development such as emotion recognition (McGivern, Andersen, Byrd, Mutter, & Reilly, 2002; Ross, Polson, & Grosbras, 2012), and face recognition (Carey et al., 1980; Lawrence et al., 2008). While development of the cognitive abilities has been investigated for a long time, developmental changes in motivation have received little attention until recently. Unfortunately, out of the three sub-components of social motivation, social seeking is a particularly neglected domain. The only study exploring the developmental trajectory (10-25 year) of two elements of social seeking: reward anticipation and reward outcome (i.e. viewing the reward), reported that while brain activation for reward anticipation seems to increase with age, activation related to reward outcome declines with

age (Hoogendam, Kahn, Hillegers, van Buuren, & Vink, 2013). There are no other cross-sectional or longitudinal studies exploring development of social seeking in typical or ASD groups.

In chapter 3, 4, and 5 of this thesis, an attempt was made to bridge this gap by exploring social seeking in adults and adolescents with ASD and typical participants from 4-20 year of age. The findings showed that participants with ASD have low reward value of social stimuli in both adolescent and adult groups, and the developmental course of social seeking might have a non-linear progression for typical people. This non-linear progression follows a quadratic "U" curve in which typical children show higher social seeking tendency, pre-adolescents show a decline in it, and older adolescents and adults show higher social seeking. The behavioural data of Hoogendam et al (2013) also shows that the reaction time for the rewarding trials decreases with age, indicating higher social seeking with age. Yet the unavailability of the younger group (4-9 years) might hide the decline in the social seeking during pre-adolescence. The data from the current research as well as Hoogendam et al are cross-sectional in nature, which does not allow us to eliminate the influence of cohort based demographic difference in the data.

Due to limited research in this area it is hard to conclude if the decline observed in pre-adolescent's social seeking in chapter 5 is a result of general change in motivation or if it was a manifestation of otherwise reported narrow social interest in this age group (Knoll et al., 2015; Wolf et al., 2015). This strongly indicates the need for further resrach in this area.

7.2 Social motivation: Is it an elephant being explored blindfolded?

The latest definition of social motivation, includes several sub-concepts that can be evaluated using various methods (Chevallier, Kohls, et al., 2012). These methods might claim to measure social motivation but as they focus on different components within it, the findings produced from one method might not be the same as findings from the other method. This does not necessarily show superiority of one method over the others, but it might result in conflicting claims about social motivation in the same group. For example, methods such as eye-tracking or gaze fixation primarily evaluate the social-orientation component of social motivation, whereas methods involving effort-based response evaluate social seeking. A latest review of the visual orienting for social stimuli in adults with and without ASD suggested that people with ASD may not have a qualitative difference in their visual fixation for social stimuli (Guillon, Hadjikhani, Baduel, & Rogé, 2014). On the other hand, a review evaluating reward value of social and non-social stimuli using neurobiological methods, suggested that people with ASD might have disrupted reward responsiveness for social stimuli but not for non-social (Kohls et al., 2012). Thus the same target population tested using two different methods shows intact social orientation, but deficits in social wanting. The findings from these studies might appear to be conflicting, however if explored closely they may present a more comprehensive understanding of social motivation in ASD. These findings can be interpreted in a different way such as, people with ASD might not have difficulty orienting to important social cues however they may not experience pleasure from the social interactions, which might result in lower motivation to explore social stimuli and seek them in future.

Chapter 6 of this thesis tried to explore if the two methods claiming to be measuring same component of social motivation, produce same results. The approach-avoidance (AA) and the CAM paradigms were used with the same set of undergraduate students. Both these tasks use effort as a measure of motivation to seek a stimulus. The AA task presents one stimulus at a time and participants make an effort to either look at it or avoid it. The CAM paradigm presents a forced choice between two stimuli to choose from, and participants are encouraged to make a trade-off between their preference and the effort. While the AA task might be helpful in understanding the seeking motivation for a set of stimuli against 'doing nothing', the CAM paradigm produces an estimate of seeking motivation for a stimulus in relation to another stimulus. The findings suggested that though these two measures might be measuring social seeking using behavioural effort, the presentation of stimuli and the nature of task might make the CAM paradigm more sensitive to identify any difference in social seeking in relation to the autistic traits of the participants. This indicates that not only between the components but even within any one component the methods used may tap onto different psychological factors that can present dissimilar findings from each other.

Hence, this raises the question if the researchers exploring social motivation might be reaching different conclusions due to the minute differences in the methods used. Also, do we need to understand the apparently conflicting findings from these studies in a comprehensive manner to understand social difficulties in ASD?

7.3 Can reduced social seeking be seen as: increased non-social preference rather than low social preference?

As the CAM paradigm is based on binary choice, the preference for one stimulus always corresponds to the non-preference for the other stimulus. In chapters 3 and 4 of this research, participants with ASD showed low preference for social stimuli, which corresponds with the high preference for non-social stimuli. This raises an important question: if the findings from these studies support reduced social motivation theory of ASD or do they indicate "higher motivation for non-social stimuli in ASD". In the study by Watson et al (2015) participants with ASD distinctly preferred the high autism interest non-social stimuli with varied monetary reward over the scrambled (non-social high autism interest) images with constant reward. Watson et al therefore conclude that people with ASD have higher reward value for specific high autism interest non-social stimuli, but are not different from the typical group in their preference for social and other non-social stimuli. Hence, these results support the idea for high non-social preference in ASD. On the contrary, a study by Delmonte et al (2012) found that people with ASD show hypo-activation of the reward system of brain only in response to the social condition and not the non-social, hence supporting reduced social motivation theory.

In forced choice task based studies the alternative conclusions may look like two sides of the same coin, as increase reward value for one mirrors the decreased reward value for other. Nevertheless, these two may have very different implications for clinical management of the social difficulties in ASD. The suggestion of 'reduced social motivation' might imply that the aim of the intervention needs to be 'increasing the reward value of all the social

interaction'. Alternatively, the argument that non-social stimuli holds very high reward value for those with ASD would imply interventions should aim at reducing or neutralising the reward value of these stimuli to encourage more attention to social interactions. Therefore, it is important to disentangle these closely linked conclusions. One way of doing it might be presenting more than two choices on each trial of a paradigm. For example, in a three choice CAM paradigm, preference for only one stimulus over the other two would indicate relatively high reward value of it, while preference for any two but not the third one would indicate relatively lower reward value for the least chosen stimulus. This can help exploring if low social preference in ASD is a result of low reward value for it or high reward value for the comparative stimuli. It might also help in establishing the hierarchy of reward value of different stimuli in ASD.

7.4 Is reduced social preference in ASD a generalised concept or is it limited to direct eye-gaze conditions only?

In chapter 2 and 3, participants were compared for the preference for social direct gaze, social averted gaze, and non-social stimuli. In both the studies, social direct gaze was preferred distinctly more than the other two stimuli by the typical groups, while the ASD group showed low preference for both social stimuli. However, in the later adaptation of the task (chapter 4), the averted gaze condition was removed to reduce the task duration. This change in the paradigm leaves a primary debate unresolved i.e. if the low social motivation in ASD is limited to the direct gaze social stimuli or does it extend equally to all the social stimuli?

Gaze direction can have important social cues depending on the context (Hamilton, 2015). While in some situations prolonged direct eye-gaze signals threat or danger (Ellsworth, Carlsmith, & Henson, 1972), in other it might be a sign of attraction or liking (Kellerman, Lewis, & Laird, 1989). Direct eye contact might be hyper-arousing for people with ASD (Kylliäinen & Hietanen, 2006) which might be a reason why it results in stronger avoidance response than stimuli without eye contact (Chawarska, Macari, & Shic, 2012). However, this evidence is limited to the social orientation component of social motivation. The study discussed in chapter 3, compared social seeking in people with ASD using social stimuli with direct and averted gaze condition. The results here suggested that people with ASD may not prefer any one of these over the other, though they definitely prefer non-social stimuli against both the social stimuli. Similarly, findings from typical adults in chapter 2, showed that the severity of autistic traits might not be a reliable predictor of preference between direct gaze vs averted gaze stimuli, though participants with higher autistic traits prefer non-social stimuli against both the social stimuli (Dubey et al., 2015). Unfortunately, there are no other studies exploring social seeking in relation to direct vs averted gaze social cues. Therefore, despite the evidence for weaker 'orientation' to more engaging social cues (direct eye contact) in ASD, it is hard to say if the same is true for other components of social motivation. Moreover, the evidence of reduced social orientation in ASD for specific social cues, raises the question if this is the aversion from intensive social interactions or lower approach motivation. I will discuss the evidence supporting/countering this idea in the next section.

7.5 Is reduced social seeking in ASD a result of low reward value of social interaction or aversion from them?

As discussed in the previous section, the lower interest in social interaction in ASD might be attributed to either low reward value for social interactions or to the aversion from them. Silva et al (2015) proposed that adolescents with ASD have higher 'incentive salience' or reward value for animated stimuli like cartoons than the life-like social stimuli. However this conclusion is focused only on one aspect of the results. The major findings of the study suggested that participants pushed away (avoided) the life-like social stimuli and pulled (approached) the cartoon stimuli. Therefore it supports both, aversion from real social stimuli and approach for animated stimuli. Also, unlike forced choice tasks Silva et al used an approach-avoidance task in which stimuli are presented one by one and not in competition with each other, hence the preference for one stimulus does not correspond to the avoidance of other. Therefore, the results obtained from this study can be interpreted in any direction i.e. aversion from social, approach for non-social, or perhaps the presence of both. In a different approach to understand the reason for social difficulties in ASD Hintzen, Delespaul, van Os, Myin-Germeys (2010) used a 'structured diary technique' and collected a sample of narratives about the personal experiences of people with pervasive developmental disorders (PDD). They found that though people with ASD expressed a desire to interact with others they may not make attempts to do so due to high social anxiety. This suggests that social withdrawal in ASD might be due to social aversion rather than low motivation. Louwerse et al (2013) examined the autonomic response to social and non-social stimuli in adolescents with and without ASD. Contrary

to the evidence above, this study found no atypical autonomic response to social stimuli in people with ASD, therefore providing evidence against the social aversion theory of ASD. The results presented in chapter 3 and 4 of the current research, also showed that ASD participants were flexible in their choice behaviour. Though they preferred non-social stimuli on most of the trials, when the effort related to it was increased they switched to look at social stimuli, which was easier to get. This suggests that the non-preference for social stimuli might be the result of lower reward value of social stimuli rather than aversion of them.

The research discussed above demonstrates both, evidence for and against the two sides of the debate. It must be noted that most of the studies discussed here (except studies from this thesis), once again refer to the social orientation or social attention rather than social seeking. Therefore, it is difficult to conclude if the low social seeking seen in ASD emerges from low reward value of social interactions or from aversion of it.

Overall the discussion from the previous subsections (7.3, 7.4, and 7.5) suggests that the questions raised here might be overlapping. For example, if the lack of social seeking in ASD is due to higher interest in non-social stimuli, specific avoidance of some intense social stimuli (i.e. direct gaze), or generalised aversion from all social stimuli. However, each of these has important implications for future clinical research in ASD. Higher interest in non-social stimuli might imply that the interventions for social difficulties in ASD need to aim at increasing the value of social stimuli while lowering the value of non-social stimuli, specific avoidance from social stimuli might indicate specific skill training to deal with the complex social situations, and generalised social aversion might signify intensive training in social skills to control anxiety.

Therefore, delineating these apparently overlapping questions needs to be the focus of future research in social difficulties in ASD.

7.6 Reduced social motivation: A cause or a consequence

Chevallier, Kohls, et al (2012) claim that reduced social motivation might be the primary deficit limiting a child's chances to have social interactions and resulting in later difficulties with social cognition. Therefore, reduced social motivation is the cause of social difficulties in ASD and other social cognition deficits are the consequence of this. Chevallier, Kohls, et al present four key points to support their argument; firstly, social motivation deficits are more universal in ASD than the deficits in social cognition. However, this argument might not be completely valid. Like any other field of investigation, social motivation has also received mixed findings. While some studies support the theory (Chita-Tegmark, 2016; Delmonte et al., 2012; Dubey et al., 2015; Hanley et al., 2014; Kohls et al., 2012), others refute it (Ewing et al., 2013; Guillon et al., 2014; Nele, Ellen, Petra, & Herbert, 2015; Watson et al., 2015) or provide mixed results (Deckers et al., 2014). Furthermore, none of the studies reporting lack of social seeking, social maintenance, and social orientation in ASD, claim that all the participants in this group conformed to the same behaviour. Most of the data has individual differences within the sample indicating that some people with ASD might show behaviours similar to typicals but due to an overall group effect they go unnoticed. In chapter 3, 4 of this research, though I present the group results supporting low social motivation in ASD, a closer look at the data reveals that within ASD there are some participants who preferred social stimuli and made an effort for it, some who strongly avoided social stimuli, and

others who made a trade-off between stimuli preference and effort. The data points at these extremes are generally overlooked by the statistical analyses used to understand groups. In most of the studies, the small number of participants makes it difficult to have a secondary analysis to explore differences within ASD.

Further, evidence of individual differences in social motivation comes from the large epidemiological survey of social difficulties in children by Wing and Gould (1979). This survey suggested that ASD is generally comprised of three social subtypes– 'aloof', 'passive' and 'active but odd'. Aloof is the subtype that includes people with limited interest in social interactions and high preference for solitary activities. Passive, includes people who might not make any initiative to have social interactions but can be involved in it if other people make an effort to engage them. Finally the active-but-odd group, includes people who express a desire to have social interactions and also make attempts to do so, but lack essential skills to have lasting social relations. According to this sub-division it appears that perhaps social motivation deficits might be more prominent in 'aloof' than 'active but odd' sub-groups. As these social subtypes are derived from a large epidemiological study of social impairments in children, hence they strongly link to the wider population of people with ASD than most of the experimental studies which rely on small samples of people with ASD who are able to understand experimental instructions. Keeping these arguments in mind we need to be more careful while suggesting that social motivation is a more universal deficit in ASD than other social cognition deficits.

The second point raised by Chevallier, Kohls, et al was the evidence of lower interest in social stimuli in infants who were later diagnosed to have ASD (Elsabbagh et al., 2012) and lack of any such evidence for social cognitive

deficits at such an early age in ASD. The evaluation of social cognition such as Theory of Mind (TOM) is difficult for such a young age group. Though recently researchers have developed methods to overcome this limitation (Sodian & Kristen, 2015), despite this there are no studies available to suggest if infants who are later diagnosed with ASD show any deficits in TOM. In the absence of the evidence to counter the claims made by Chevallier, Kohls, et al, it will be reasonable to accept them until we have further data.

The third point made by Chevallier, Kohls, et al was that diminished social attention would result in poor social cognition irrespective of the diagnostic category of the person. In this claim, Chevallier, Kohls, et al assume that attention is an integral part of motivation and not cognition. Contrary to that, attention is seen as the primary component in the basic evaluation of social-cognition (Hanley et al., 2014), and it is also believed to have higher top-down cognitive control (Kuhn, Teszka, Tenaw, & Kingstone, 2016). Therefore, a deficit in the ability to orient to social cues might be strongly linked to deficits of social cognition and not only a deficit in social motivation. In other words, a child's poor attention to a social cue may also be interpreted as a response to an inability to make sense of these cues rather than an inability to experience any reward from them.

The final point by Chevallier, Kohls, et al also relates to social attention, as they emphasise that any improvement in the performance of participants when their attention is deliberately focused on important social cues indicates of spared social cognition but lack of spontaneous integration of these cues while processing the information. Chevallier, Kohls, et al also present a large set of evidence supporting this claim (Kahana-Kalman & Goldman, 2008; Pierce & Redcay, 2008; Ristic et al., 2005; Senju, Southgate, White, & Frith, 2009;

Wang, Lee, Sigman, & Dapretto, 2007). This indeed shows the crucial role of spontaneous attention on the performance on tasks of social cognition and therefore supports the theory of reduced social motivation.

Overall, the discussion suggests that social motivation might be a primary cause resulting in difficulties in social cognition in ASD, however if this stands true for all the people with ASD is yet to be explored.

7.7 Overall Conclusion

In conclusion, measuring social seeking in a large group of people with and without ASD, while also controlling for the effect of low level visual features and varied levels of cognitive and language abilities, is possible using the Choose a Movie (CAM) paradigm. This task has successfully shown high reliability across samples, and sensitivity against previously used meaures of social seeking. Using the CAM paradigm, it seems that people with ASD have a lower reward value for social stimuli, resulting in reduced social motivation. This low preference for social stimuli is less likley to be due to social aversion, as the participants with ASD were able to switch their prefrence if the effort was increased.

Even though the reduced social seeking seemed to exist in both adult and adolecents with ASD, the gap between this group and the typical matched participants might reduce during preadoelscence. This is primarily caused by the changes in the social seeking in typical preadolescents than any change in ASD. In the future, the nature of developmental changes in social seeking tendency in both the groups needs to be explored more to understand social difficulties in ASD.

REFERENCES

Achenbach, T. M., McConaughy, S. H., & Howell, C. T. (1987). Child/adolescent behavioral and emotional problems: Implications of cross-informant correlations for situational specificity. *Psychological Bulletin*, *101*(2), 213–232. doi:10.1037/0033-2909.101.2.213

Aharon, I., Etcoff, N., Ariely, D., Chabris, C. F., O'Connor, E., & Breiter, H. C. (2001). Beautiful faces have variable reward value: fMRI and behavioral evidence. *Neuron*, *32*(3), 537–51. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/11709163

Aldridge, M. A., Stone, K. R., Sweeney, M. H., & Bower, T. G. R. (2000a). Preverbal children with autism understand the intentions of others. *Developmental Science*, *3*(3), 294–301. doi:10.1111/1467-7687.00123

Aldridge, M. A., Stone, K. R., Sweeney, M. H., & Bower, T. G. R. (2000b). Preverbal children with autism understand the intentions of others. *Developmental Science*, *3*(3), 294–301. doi:10.1111/1467-7687.00123

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: American Psychiatric Association.

Anderson, B. A., Laurent, P. A., & Yantis, S. (2011). Value-driven attentional capture. *Proceedings of the National Academy of Sciences of the United States of America*, *108*(25), 10367–10371. doi:10.1073/pnas.1104047108

Bailenson, J. N., Blascovich, J., & Guadagno, R. E. (2008). Self-

representations in immersive virtual environments. *Journal of Applied Social Psychology*, *38*(11), 2673–2690. doi:10.1111/j.1559-1816.2008.00409.x

Baron-Cohen, S. (1988). Social and pragmatic deficits in autism: Cognitive or affective? *Journal of Autism and Developmental Disorders*, *18*(3), 379–402. doi:10.1007/BF02212194

Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a “theory of mind”? *Cognition*, *21*(1), 37–46. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/2934210

Baron-Cohen, S., & Wheelwright, S. (1999). “Obsessions” in children with autism or Asperger syndrome. Content analysis in terms of core domains of cognition. *The British Journal of Psychiatry : The Journal of Mental Science*, *175*, 484–90. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/10789283

Baron-Cohen, S., & Wheelwright, S. (2003). The Friendship Questionnaire: an investigation of adults with Asperger syndrome or high-functioning autism, and normal sex differences. *Journal of Autism and Developmental Disorders*, *33*(5), 509–17. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/14594330

Baron-Cohen, S., Wheelwright, S., Skinner, R., 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*(1), 5–17. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/11439754

Baumeister, R. F., & Leary, M. R. (1995). The need to belong: desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin*, *117*(3), 497–529. doi:10.1037/0033-2909.117.3.497

Bauminger, N., & Kasari, C. (2000). Loneliness and Friendship in High-Functioning Children with Autism. *Child Development*, *71*(2), 447–456. doi:10.1111/1467-8624.00156

Bayliss, A. P., Paul, M. A., Cannon, P. R., & Tipper, S. P. (2006). Gaze cuing and affective judgments of objects: I like what you look at. *Psychonomic Bulletin & Review*, *13*(6), 1061–1066. doi:10.3758/BF03213926

Begeer, S., Gevers, C., Clifford, P., Verhoeve, M., Kat, K., Hoddenbach, E., & Boer, F. (2011). Theory of Mind Training in Children with Autism: A Randomized Controlled Trial. *Journal of Autism and Developmental Disorders*, *41*(8), 997–1006. doi:10.1007/s10803-010-1121-9

Belin, P., Zatorre, R. J., Lafaille, P., Ahad, P., & Pike, B. (2000). Voice-selective areas in human auditory cortex. *Nature*, *403*(6767), 309–312. doi:10.1038/35002078

Berger, H. J. C., Aerts, F. H. T. M., Spaendonck, K. P. M. van, Cools, A. R., & Teunisse, J.-P. (2003). Central Coherence and Cognitive Shifting in Relation to Social Improvement in High-Functioning Young Adults with Autism. *Journal of Clinical and Experimental Neuropsychology (Neuropsychology, Development and Cognition: Section A)*, *25*(4), 502–511. doi:10.1076/jcen.25.4.502.13870

Berridge, K. C. (2004). Motivation concepts in behavioral neuroscience.

Physiology & Behavior, *81*(2), 179–209. doi:10.1016/j.physbeh.2004.02.004

Berridge, K. C., & Robinson, T. E. (1998). What is the role of dopamine in reward: Hedonic impact, reward learning, or incentive salience? *Brain Research Reviews*. doi:10.1016/S0165-0173(98)00019-8

Berridge, K. C., Robinson, T. E., & Aldridge, J. W. (2009). Dissecting components of reward: “liking”, “wanting”, and learning. *Current Opinion in Pharmacology*, *9*(1), 65–73. doi:10.1016/j.coph.2008.12.014

Bindra, D. (1974). A motivational view of learning, performance, and behavior modification. *Psychological Review*. doi:10.1037/h0036330

Bindra, D. (1978). How adaptive behavior is produced: a perceptual-motivational alternative to response reinforcements. *Behavioral and Brain Sciences*, *1*(01), 41. doi:10.1017/S0140525X00059380

Bjork, J. M., Knutson, B., Fong, G. W., Caggiano, D. M., Bennett, S. M., & Hommer, D. W. (2004). Incentive-Elicited Brain Activation in Adolescents: Similarities and Differences from Young Adults. *Journal of Neuroscience*, *24*(8), 1793–1802. doi:10.1523/JNEUROSCI.4862-03.2004

Blakemore, S.-J. (2008). The social brain in adolescence. *Nature Reviews. Neuroscience*, *9*, 267–277. doi:10.1038/nrn2353

Blasi, A., Mercure, E., Lloyd-Fox, S., Thomson, A., Brammer, M., Sauter, D., … Murphy, D. G. M. (2011). Early specialization for voice and emotion processing in the infant brain. *Current Biology*, *21*(14), 1220–1224. doi:10.1016/j.cub.2011.06.009

Bolles, R. C. (1972). Reinforcement, expectancy, and learning. *Psychological*

Review, *79*(5), 394–409. doi:10.1037/h0033120

Boothroyd, L. G., Meins, E., Vukovic, J., & Burt, D. M. (2014). Developmental changes in children's facial preferences. *Evolution and Human Behavior*, *35*(5), 376–383. doi:10.1016/j.evolhumbehav.2014.05.002

Bora, E. (2014). Developmental Lag and Course of Cognitive Deficits From the Premorbid to Postonset Period in Schizophrenia. *American Journal of Psychiatry*, *171*(3), 369–369. doi:10.1176/appi.ajp.2013.13091283

Brody, N. (1980). Social Motivation. *Annual Review of Psychology*, *31*(1), 143–168. doi:10.1146/annurev.ps.31.020180.001043

Brüne, M. (2003). Theory of mind and the role of IQ in chronic disorganized schizophrenia. *Schizophrenia Research*, *60*(1), 57–64. doi:10.1016/S0920-9964(02)00162-7

Bussey, K. (1999). Children's categorization and evaluation of different types of lies and truths. *Child Development*, *70*(6), 1338–1347. doi:10.1111/1467-8624.00098

Cage, E., Pellicano, E., Shah, P., & Bird, G. (2013). Reputation management: Evidence for ability but reduced propensity in autism. *Autism Research*, *6*(5), 433–442. doi:10.1002/aur.1313

Calder, L., Hill, V., & Pellicano, E. (2013). "Sometimes I want to play by myself": Understanding what friendship means to children with autism in mainstream primary schools. *Autism*, *17*(3), 296–316. doi:10.1177/1362361312467866

Call, J., & Tomasello, M. (1998). Distinguishing intentional from accidental actions in orangutans (Pongo pygmaeus), chimpanzees (Pan

troglodytes) and human children (Homo sapiens). *Journal of Comparative Psychology*, *112*(2), 192–206. doi:10.1037/0735-7036.112.2.192

Campisi, J., Folan, D., Diehl, G., Kable, T., & Rademeyer, C. (2015). Social media users have different experiences, motivations, and quality of life. *Psychiatry Research*, *228*(3), 774–780. doi:10.1016/j.psychres.2015.04.042

Carey, S., Diamond, R., & Woods, B. (1980). Development of face recognition: A maturational component? *Developmental Psychology*. doi:10.1037/0012-1649.16.4.257

Caronna, E. B., Milunsky, J. M., & Tager-Flusberg, H. (2008). Autism spectrum disorders: clinical and research frontiers. *Archives of Disease in Childhood*, *93*(6), 518–523. doi:10.1136/adc.2006.115337

Carpenter, M., Pennington, B. F., & Rogers, S. J. (2001). Understanding of Others' Intentions in Children with Autism. *Journal of Autism and Developmental Disorders*, *31*(6), 589–599. doi:10.1023/A:1013251112392

Carr, E. G. (2007). Social Skills That are Not Always Social and Problems That are Not Always Problems. *Research & Practice for Persons with Severe Disabilities*, *32*(2), 110–111.

Carver, C. S., & White, T. L. (1994a). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The BIS/BAS Scales. *Journal of Personality and Social Psychology*, *67*(2), 319–333. doi:10.1037/0022-3514.67.2.319

Carver, C. S., & White, T. L. (1994b). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The BIS/BAS Scales. *Journal of Personality and Social Psychology*, *67*(2), 319–333. doi:10.1037/0022-3514.67.2.319

Cassidy, S., Mitchell, P., Chapman, P., & Ropar, D. (2015). Processing of Spontaneous Emotional Responses in Adolescents and Adults with Autism Spectrum Disorders: Effect of Stimulus Type. *Autism Research*, *8*(5), 534–544. doi:10.1002/aur.1468

Chamberlain, B., Kasari, C., & Rotheram-Fuller, E. (2007). Involvement or isolation? The social networks of children with autism in regular classrooms. *Journal of Autism and Developmental Disorders*, *37*(2), 230–42. doi:10.1007/s10803-006-0164-4

Charman, T., Baron-Cohen, S., Swettenham, J., Baird, G., Cox, A., & Drew, A. (2000). Testing joint attention, imitation, and play as infancy precursors to language and theory of mind. *Cognitive Development*, *15*(4), 481–498. doi:10.1016/S0885-2014(01)00037-5

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*(5), 781–789. doi:10.1037/0012-1649.33.5.781

Chartrand, T. L., & Bargh, J. A. (1999a). The chameleon effect: the perception-behavior link and social interaction. *Journal of Personality and Social Psychology*, *76*(6), 893–910. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/10402679

Chartrand, T. L., & Bargh, J. A. (1999b). *The chameleon effect: the perception-behavior link and social interaction. Journal of personality and social psychology* (Vol. 76). doi:10.1037/0022-3514.76.6.893

Chawarska, K., Macari, S., & Shic, F. (2012). Context modulates attention to social scenes in toddlers with autism. *Journal of Child Psychology and Psychiatry*, *53*(8), 903–913. doi:10.1111/j.1469-7610.2012.02538.x

Chawarska, K., Macari, S., & Shic, F. (2013). Decreased Spontaneous Attention to Social Scenes in 6-Month-Old Infants Later Diagnosed with Autism Spectrum Disorders. *Biological Psychiatry*. doi:10.1016/j.biopsych.2012.11.022

Chevallier, C., Grèzes, J., Molesworth, C., Berthoz, S., & Happé, F. (2012a). Brief report: Selective social anhedonia in high functioning autism. *Journal of Autism and Developmental Disorders*, *42*(7), 1504–9. doi:10.1007/s10803-011-1364-0

Chevallier, C., Grèzes, J., Molesworth, C., Berthoz, S., & Happé, F. (2012b). Brief report: Selective social anhedonia in high functioning autism. *Journal of Autism and Developmental Disorders*, *42*(7), 1504–9. doi:10.1007/s10803-011-1364-0

Chevallier, C., Huguet, P., Happé, F., George, N., & Conty, L. (2013). Salient social cues are prioritized in autism spectrum disorders despite overall decrease in social attention. *Journal of Autism and Developmental Disorders*, *43*, 1642–1651. doi:10.1007/s10803-012-1710-x

Chevallier, C., Kohls, G., Troiani, V., Brodkin, E. S., & Schultz, R. T. (2012a). The social motivation theory of autism. *Trends in Cognitive Sciences*,

16(4), 231–239. doi:10.1016/j.tics.2012.02.007

Chevallier, C., Kohls, G., Troiani, V., Brodkin, E. S., & Schultz, R. T. (2012b). The social motivation theory of autism. *Trends in Cognitive Sciences*, *16*(4), 231–9. doi:10.1016/j.tics.2012.02.007

Chevallier, C., Molesworth, C., & Happé, F. (2012). Diminished social motivation negatively impacts reputation management: autism spectrum disorders as a case in point. *PloS One*, *7*(1), e31107. doi:10.1371/journal.pone.0031107

Chevallier, C., Parish-Morris, J., McVey, A., Rump, K. M., Sasson, N. J., Herrington, J. D., & Schultz, R. T. (2015). Measuring social attention and motivation in autism spectrum disorder using eye-tracking: Stimulus type matters. *Autism Research*, n/a–n/a. doi:10.1002/aur.1479

Chita-Tegmark, M. (2016). Social attention in ASD: A review and meta-analysis of eye-tracking studies. *Research in Developmental Disabilities*, *48*, 79–93. doi:10.1016/j.ridd.2015.10.011

Choi, U.-S., Kim, S.-Y., Sim, H. J., Lee, S.-Y., Park, S.-Y., Jeong, J.-S., … Cheon, K.-A. (2015). Abnormal Brain Activity in Social Reward Learning in Children with Autism Spectrum Disorder: An fMRI Study. *Yonsei Medical Journal*, *56*(3), 705. doi:10.3349/ymj.2015.56.3.705

Clarke, A. H. (1996). Current trends in eye movement measurement techniques. In W. H. Zangemeister, H. S. Stiehl, & C. Freksa (Eds.), *Advances in Psychology* (pp. 347–364). doi:10.1016/S0166-4115(96)80087-2

Cohen, I. L., Vietze, P. M., Sudhalter, V., Jenkins, E. C., & Brown, W. T.

(1989). Parent-child dyadic gaze pattern in fragile X males and in non-fragile X males with autistic disorder. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *30*, 845–856. doi:10.1111/j.1469-7610.1989.tb00286.x

Constantino, J. N., & Gruber, C. P. (2005). *Social Responsiveness Scale^{TM} (SRS^{TM})* (2nd ed.). Los Angeles: Western Psychological Services.

Cornelissen, G., Dewitte, S., & Warlop, L. (2011). Are social value orientations expressed automatically? Decision making in the dictator game. *Personality and Social Psychology Bulletin*, *37*(8), 1080–1090. doi:10.1177/0146167211405996

Cox, A., Kohls, G., Naples, A. J., Mukerji, C. E., Coffman, M. C., Rutherford, H. J. V., … McPartland, J. C. (2015). Diminished social reward anticipation in the broad autism phenotype as revealed by event-related brain potentials. *Social Cognitive and Affective Neuroscience*. doi:10.1093/scan/nsv024

Crone, E. A., Jennings, J. R., & Van der Molen, M. W. (2004). Developmental Change in Feedback Processing as Reflected by Phasic Heart Rate Changes. *Developmental Psychology*, *40*(6), 1228–1238. doi:10.1037/0012-1649.40.6.1228

Damiano, C. R., Cockrell, D. C., Dunlap, K., Hanna, E. K., Miller, S., Bizzell, J., … Dichter, G. S. (2015). Neural mechanisms of negative reinforcement in children and adolescents with autism spectrum disorders. *Journal of Neurodevelopmental Disorders*, *7*(1), 12. doi:10.1186/s11689-015-9107-8

Davies, M. S., Dapretto, M., Sigman, M., Sepeta, L., & Bookheimer, S. Y. (2011). Neural bases of gaze and emotion processing in children with autism spectrum disorders. *Brain and Behavior*, *1*, 1–11. doi:10.1002/brb3.6

Dawson, G., Meltzoff, A. N., Osterling, J., Rinaldi, J., & Brown, E. (1998). Children with autism fail to orient to naturally occurring social stimuli. *Journal of Autism and Developmental Disorders*, *28*(6), 479–85. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9932234

de Bordes, P. F., Cox, R. F. A., Hasselman, F., & Cillessen, A. H. N. (2013). Toddlers' gaze following through attention modulation: intention is in the eye of the beholder. *Journal of Experimental Child Psychology*, *116*(2), 443–52. doi:10.1016/j.jecp.2012.09.008

De Los Reyes, A., & Kazdin, A. E. (2005). Informant Discrepancies in the Assessment of Childhood Psychopathology: A Critical Review, Theoretical Framework, and Recommendations for Further Study. *Psychological Bulletin*, *131*(4), 483–509. doi:10.1037/0033-2909.131.4.483

de Reuver, M., & Bouwman, H. (2014). Dealing with self-report bias in mobile Internet acceptance and usage studies. *Information & Management*. doi:10.1016/j.im.2014.12.002

Deckers, A., Roelofs, J., Muris, P., & Rinck, M. (2014a). Desire for social interaction in children with autism spectrum disorders. *Research in Autism Spectrum Disorders*, *8*, 449–453. doi:10.1016/j.rasd.2013.12.019

Deckers, A., Roelofs, J., Muris, P., & Rinck, M. (2014b). Desire for social

interaction in children with autism spectrum disorders. *Research in Autism Spectrum Disorders*, *8*(4), 449–453. doi:10.1016/j.rasd.2013.12.019

Deckers, A., Roelofs, J., Muris, P., & Rinck, M. (2014c). Desire for social interaction in children with autism spectrum disorders. *Research in Autism Spectrum Disorders*, *8*(4), 449–453. doi:10.1016/j.rasd.2013.12.019

Delmonte, S., Balsters, J. H., McGrath, J., Fitzgerald, J., Brennan, S., Fagan, A. J., & Gallagher, L. (2012a). Social and monetary reward processing in autism spectrum disorders. *Molecular Autism*, *3*(1), 7. doi:10.1186/2040-2392-3-7

Delmonte, S., Balsters, J. H., McGrath, J., Fitzgerald, J., Brennan, S., Fagan, A. J., & Gallagher, L. (2012b). Social and monetary reward processing in autism spectrum disorders. *Molecular Autism*, *3*(1), 7. doi:10.1186/2040-2392-3-7

Delmonte, S., Balsters, J. H., McGrath, J., Fitzgerald, J., Brennan, S., Fagan, A. J., & Gallagher, L. (2012c). Social and monetary reward processing in autism spectrum disorders. *Molecular Autism*, *3*(1), 7. doi:10.1186/2040-2392-3-7

Demurie, E., Roeyers, H., Baeyens, D., & Sonuga-Barke, E. (2012). The effects of monetary and social rewards on task performance in children and adolescents: Liking is not enough. *International Journal of Methods in Psychiatric Research*, *21*(4), 301–310. doi:10.1002/mpr.1370

DePaulo, B. M., & Bell, K. L. (1996). *Truth and investment: lies are told to*

those who care. Journal of personality and social psychology (Vol. 71). doi:10.1037/0022-3514.71.4.703

DePaulo, B. M., & Kashy, D. A. (1998). Everyday lies in close and casual relationships. *Journal of Personality and Social Psychology*, *74*, 63–79. doi:10.1037/0022-3514.74.1.63

Derfler-Rozin, R., Pillutla, M., & Thau, S. (2010). Social reconnection revisited: The effects of social exclusion risk on reciprocity, trust, and general risk-taking. *Organizational Behavior and Human Decision Processes*, *112*(2), 140–150. doi:10.1016/j.obhdp.2010.02.005

Di Giorgio, E., Turati, C., Altoè, G., & Simion, F. (2012). Face detection in complex visual displays: an eye-tracking study with 3- and 6-month-old infants and adults. *Journal of Experimental Child Psychology*, *113*(1), 66–77. doi:10.1016/j.jecp.2012.04.012

Diamond, A., & Lee, K. (2011). Interventions Shown to Aid Executive Function Development in Children 4 to 12 Years Old. *Science*, *333*(6045), 959–964. doi:10.1126/science.1204529

Dichter, G. S., Richey, J. A., Rittenberg, A. M., Sabatino, A., & Bodfish, J. W. (2012a). Reward circuitry function in autism during face anticipation and outcomes. *Journal of Autism and Developmental Disorders*, *42*(2), 147–60. doi:10.1007/s10803-011-1221-1

Dichter, G. S., Richey, J. A., Rittenberg, A. M., Sabatino, A., & Bodfish, J. W. (2012b). Reward circuitry function in autism during face anticipation and outcomes. *Journal of Autism and Developmental Disorders*, *42*(2), 147–60. doi:10.1007/s10803-011-1221-1

Donaldson, S. I., & Grant-Vallone, E. J. (2002). Understanding self-report bias in organizational behavior research. *Journal of Business and Psychology*, *17*, 245–260. doi:10.1023/A:1019637632584

Driver, J., Davis, G., Ricciardelli, P., Kidd, P., Maxwell, E., & Baron-Cohen, S. (1999). Gaze perception triggers reflexive visuospatial orienting. doi:10.1080/135062899394920

Dubey, I., Ropar, D., & Hamilton, A. F. de C. (2015). Measuring the value of social engagement in adults with and without autism. *Molecular Autism*, *6*, 35. doi:10.1186/s13229-015-0031-2

Dumontheil, I. (2015). Development of the social brain during adolescence. *Psicología Educativa*, *21*(2), 117–124. doi:10.1016/j.pse.2015.08.001

Dumontheil, I., Apperly, I. A., & Blakemore, S.-J. (2010). Online usage of theory of mind continues to develop in late adolescence. *Developmental Science*, *13*(2), 331–8. doi:10.1111/j.1467-7687.2009.00888.x

Dunn, Dunn, Whetton, & Burley. (1997). *British Picture Vocabulary Scale - Third Edition (BPVS-3)* (3rd ed.). GL assessment.

Ecklund-Flores, L., & Turkewitz, G. (1996). Asymmetric headturning to speech and nonspeech in human newborns. *Developmental Psychobiology*, *29*(3), 205–217. doi:10.1002/(SICI)1098-2302(199604)29:3<205::AID-DEV2>3.0.CO;2-V

Ellsworth, P. C., Carlsmith, J. M., & Henson, A. (1972). The stare as a stimulus to flight in human subjects: A series of field experiments. *Journal of Personality and Social Psychology*, *21*(3), 302–311. doi:10.1037/h0032323

Elsabbagh, M., Mercure, E., Hudry, K., Chandler, S., Pasco, G., Charman, T., … Johnson, M. H. (2012). Infant neural sensitivity to dynamic eye gaze is associated with later emerging autism. *Current Biology : CB*, *22*(4), 338–42. doi:10.1016/j.cub.2011.12.056

Enter, D., Spinhoven, P., & Roelofs, K. (2014). Alleviating social avoidance: Effects of single dose testosterone administration on approach–avoidance action. *Hormones and Behavior*, *65*(4), 351–354. doi:10.1016/j.yhbeh.2014.02.001

Epstein, L. H., Wright, S. M., Paluch, R. A., Leddy, J., Hawk, L. W., Jaroni, J. L., … Lerman, C. (2004). Food hedonics and reinforcement as determinants of laboratory food intake in smokers. *Physiology & Behavior*, *81*(3), 511–7. doi:10.1016/j.physbeh.2004.02.015

Ewing, L., Pellicano, E., & Rhodes, G. (2013). Using effort to measure reward value of faces in children with autism. *PloS One*, *8*(11), e79493. doi:10.1371/journal.pone.0079493

Farroni, T., Csibra, G., Simion, F., & Johnson, M. H. (2002). Eye contact detection in humans from birth. *Proceedings of the National Academy of Sciences of the United States of America*, *99*(14), 9602–5. doi:10.1073/pnas.152159999

Feero, W. G., Guttmacher, A. E., Mefford, H. C., Batshaw, M. L., & Hoffman, E. P. (2012). Genomics, Intellectual Disability, and Autism. *New England Journal of Medicine*, *366*(8), 733–743. doi:10.1056/NEJMra1114194

Fletcher-Watson, S., Findlay, J. M., Leekam, S. R., & Benson, V. (2008). Rapid detection of person information in a naturalistic scene. *Perception*,

37(4), 571–583. doi:10.1068/p5705

Flores, A., Münte, T. F., & Doñamayor, N. (2015). Event-related EEG responses to anticipation and delivery of monetary and social reward. *Biological Psychology*, *109*, 10–19. doi:10.1016/j.biopsycho.2015.04.005

Foulkes, L., Bird, G., Gökçen, E., McCrory, E., & Viding, E. (2015). Common and Distinct Impacts of Autistic Traits and Alexithymia on Social Reward. *PLOS ONE*, *10*(4), e0121018. doi:10.1371/journal.pone.0121018

Fox, R., & McDaniel, C. (1982). The perception of biological motion by human infants. *Science (New York, N.Y.)*, *218*(4571), 486–487. doi:10.1126/science.7123249

Frank, M. C., Amso, D., & Johnson, S. P. (2014). Visual search and attention to faces during early infancy. *Journal of Experimental Child Psychology*, *118*, 13–26. doi:10.1016/j.jecp.2013.08.012

Frank, M. C., Vul, E., & Johnson, S. P. (2009). Development of infants' attention to faces during the first year. *Cognition*, *110*(2), 160–170. doi:10.1016/j.cognition.2008.11.010

Freeth, M., Foulsham, T., & Kingstone, A. (2013). What Affects Social Attention? Social Presence, Eye Contact and Autistic Traits. *PLoS ONE*, *8*(1). doi:10.1371/journal.pone.0053286

Frith, U., & Frith, C. D. (2003). Development and neurophysiology of mentalizing. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *358*(1431), 459–473. doi:10.1098/rstb.2002.1218

Fu, G., & Lee, K. (2007a). Social grooming in the kindergarten: the emergence

of flattery behavior. *Developmental Science*, *10*(2), 255–65. doi:10.1111/j.1467-7687.2007.00583.x

Fu, G., & Lee, K. (2007b). Social grooming in the kindergarten: the emergence of flattery behavior. *Developmental Science*, *10*(2), 255–65. doi:10.1111/j.1467-7687.2007.00583.x

Gardner, W. L., Pickett, C. L., & Brewer, M. B. (2000). Social Exclusion and Selective Memory: How the Need to belong Influences Memory for Social Events. *Personality and Social Psychology Bulletin*, *26*(4), 486–496. doi:10.1177/0146167200266007

Geen, R. G. (1991). Social motivation. *Annual Review of Psychology*, *42*, 377–99. doi:10.1146/annurev.ps.42.020191.002113

Giedd, J. N., Blumenthal, J., Jeffries, N. O., Castellanos, F. X., Liu, H., Zijdenbos, A., … Rapoport, J. L. (1999). No Title. *Nature Neuroscience*, *2*(10), 861–863. doi:10.1038/13158

Gliga, T., & Csibra, G. (2007). Seeing the face through the eyes: a developmental perspective on face expertise. *Progress in Brain Research*. doi:10.1016/S0079-6123(07)64018-7

Gliga, T., Elsabbagh, M., Andravizou, A., & Johnson, M. (2009). Faces Attract Infants' Attention in Complex Displays. *Infancy*, *14*(5), 550–562. doi:10.1080/15250000903144199

Gluckman, M., & Johnson, S. P. (2013). Attentional capture by social stimuli in young infants. *Frontiers in Psychology*, *4*, 527. doi:10.3389/fpsyg.2013.00527

Goren, C. C., Sarty, M., & Wu, P. Y. (1975). Visual following and pattern

discrimination of face-like stimuli by newborn infants. *Pediatrics*, *56*(4), 544–9. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/1165958

Gosselin, P., Kirouac, G., & Doré, F. Y. (1995). Components and recognition of facial expression in the communication of emotion by actors. *Journal of Personality and Social Psychology*, *68*(1), 83–96. doi:10.1037/0022-3514.68.1.83

Guillon, Q., Hadjikhani, N., Baduel, S., & Rogé, B. (2014). Visual social attention in autism spectrum disorder: Insights from eye tracking studies. *Neuroscience & Biobehavioral Reviews*, *42*, 279–297. doi:10.1016/j.neubiorev.2014.03.013

Haffey, A., Press, C., O'Connell, G., & Chakrabarti, B. (2013). Autistic Traits Modulate Mimicry of Social but not Nonsocial Rewards. *Autism Research : Official Journal of the International Society for Autism Research*. doi:10.1002/aur.1323

Haidt, J. (2007). The new synthesis in moral psychology. *Science (New York, N.Y.)*, *316*(5827), 998–1002. doi:10.1126/science.1137651

Hamilton, A. F. de C. (2015). Gazing at me: the importance of social meaning in understanding direct gaze cues. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *20150080*. doi:10.1098/rstb.2015.0080

Hanley, M., McPhillips, M., Mulhern, G., & Riby, D. M. (2012). Spontaneous attention to faces in Asperger Syndrome using ecologically valid static stimuli. *Autism*. doi:10.1177/1362361312456746

Hanley, M., McPhillips, M., Mulhern, G., & Riby, D. M. (2013). Spontaneous

attention to faces in Asperger syndrome using ecologically valid static stimuli. *Autism*, *17*(6), 754–761. doi:10.1177/1362361312456746

Hanley, M., Riby, D. M., McCormack, T., Carty, C., Coyle, L., Crozier, N., … McPhillips, M. (2014). Attention during social interaction in children with autism: Comparison to specific language impairment, typical development, and links to social cognition. *Research in Autism Spectrum Disorders*, *8*(7), 908–924. doi:10.1016/j.rasd.2014.03.020

Happé, F. G. E. (1995). Understanding Minds and Metaphors: Insights from the Study of Figurative Language in Autism. *Metaphor and Symbolic Activity*, *10*(4), 275–295. doi:10.1207/s15327868ms1004_3

Happé, F. G. E. (1997). Central coherence and theory of mind in autism: Reading homographs in context. *British Journal of Developmental Psychology*, *15*(1), 1–12. doi:10.1111/j.2044-835X.1997.tb00721.x

Hauck, M., Fein, D., Waterhouse, L., & Feinstein, C. (1995). Social initiations by autistic children to adults and other children. *Journal of Autism and Developmental Disorders*, *25*(6), 579–595. doi:10.1007/BF02178189

Havermans, R. C. (2012). How to tell where “liking” ends and “wanting” begins. *Appetite*, *58*(1), 252–255. doi:10.1016/j.appet.2011.10.013

Hayden, B. Y., Parikh, P. C., Deaner, R. O., & Platt, M. L. (2007). Economic principles motivating social attention in humans. *Proceedings. Biological Sciences / The Royal Society*, *274*(1619), 1751–6. doi:10.1098/rspb.2007.0368

Healey, K. M., Penn, D. L., Perkins, D., Woods, S. W., & Addington, J. (2013). Theory of mind and social judgments in people at clinical high risk of

psychosis. *Schizophrenia Research*, *150*(2-3), 498–504. doi:10.1016/j.schres.2013.08.038

Heide, W., Koenig, E., Trillenberg, P., Kompf, D., & Zee, D. S. (1999). Electrooculography:technical standards and applications. In G. Deuschl & A. Eisen (Eds.), *Recommandations for the practice of clinical neurophysiology: guidelines of international federation of clinical physiology (EEG suppl. 52)* (pp. 223–240). Elsevier Science B.V. Retrieved from http://www.clinph-journal.com/pb/assets/raw/Health Advance/journals/clinph/Chapter5.pdf

Herba, C. M., Landau, S., Russell, T., Ecker, C., & Phillips, M. L. (2006). The development of emotion-processing in children: Effects of age, emotion, and intensity. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *47*, 1098–1106. doi:10.1111/j.1469-7610.2006.01652.x

Hess, E. H., & Polt, J. M. (1960). Pupil Size as Related to Interest Value of Visual Stimuli. *Science*, *132*(3423), 349–350. doi:10.1126/science.132.3423.349

Hezel, D. M., & McNally, R. J. (2014). Theory of mind impairments in social anxiety disorder. *Behavior Therapy*, *45*(4), 530–540. doi:10.1016/j.beth.2014.02.010

Hill, J. L., Patel, S., Gu, X., Seyedali, N. S., Bachevalier, J., & Sereno, A. B. (2010). Social orienting: Reflexive versus voluntary control. *Vision Research*, *50*, 2080–2092. doi:10.1016/j.visres.2010.07.020

Hill, W. F. (1963). *Learning*. London: Methuen.

Hills, P. J., & Lewis, M. B. (2011). The own-age face recognition bias in

children and adults. *Quarterly Journal of Experimental Psychology (2006)*, *64*(1), 17–23. doi:10.1080/17470218.2010.537926

Hintzen, A., Delespaul, P., van Os, J., & Myin-Germeys, I. (2010). Social needs in daily life in adults with Pervasive Developmental Disorders. *Psychiatry Research*, *179*(1), 75–80. doi:10.1016/j.psychres.2010.06.014

Hobson, J. A., Harris, R., García-Pérez, R., & Hobson, R. P. (2009). Anticipatory concern: a study in autism. *Developmental Science*, *12*(2), 249–63. doi:10.1111/j.1467-7687.2008.00762.x

Hobson, R. P. (1993). *Autism and the Development of Mind*. Taylor & Francis Group.

Hoogendam, J. M., Kahn, R. S., Hillegers, M. H. J., van Buuren, M., & Vink, M. (2013). Different developmental trajectories for anticipation and receipt of reward during adolescence. *Developmental Cognitive Neuroscience*, *6*, 113–124. doi:10.1016/j.dcn.2013.08.004

Huizinga, M., Dolan, C. V., & van der Molen, M. W. (2006). Age-related change in executive function: Developmental trends and a latent variable analysis. *Neuropsychologia*, *44*(11), 2017–2036. doi:10.1016/j.neuropsychologia.2006.01.010

Hull, C. (1943). *Principles of behaviour*. New York: Appleton-Century-Crofts.

Itier, R. J., Villate, C., & Ryan, J. D. (2007). Eyes always attract attention but gaze orienting is task-dependent: evidence from eye movement monitoring. *Neuropsychologia*, *45*(5), 1019–28. doi:10.1016/j.neuropsychologia.2006.09.004

Izuma, K., Matsumoto, K., Camerer, C. F., & Adolphs, R. (2011). Insensitivity

to social reputation in autism. *Proceedings of the National Academy of Sciences of the United States of America*, *108*(42), 17302–7. doi:10.1073/pnas.1107038108

Johnson, M. H., Dziurawiec, S., Ellis, H., & Morton, J. (1991). Newborns' preferential tracking of face-like stimuli and its subsequent decline. *Cognition*, *40*(1-2), 1–19. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/1786670

Jolliffe, T., & Baron-Cohen, S. (1999). A test of central coherence theory: Linguistic processing in high-functioning adults with autism or Asperger syndrome: is local coherence impaired? *Cognition*, *71*(2), 149–185. doi:10.1016/S0010-0277(99)00022-0

Joseph, R. M., Ehrman, K., McNally, R., & Keehn, B. (2008). Affective response to eye contact and face recognition ability in children with ASD. *Journal of the International Neuropsychological Society : JINS*, *14*(6), 947–55. doi:10.1017/S1355617708081344

Joseph, R. M., & Tager–Flusberg, H. (2004). The relationship of theory of mind and executive functions to symptom type and severity in children with autism. *Development and Psychopathology*, *16*(01). doi:10.1017/S095457940404444X

Joseph, R. M., & Tanaka, J. (2003). Holistic and part-based face recognition in children with autism. *Journal of Child Psychology and Psychiatry*, *44*(4), 529–542. doi:10.1111/1469-7610.00142

Kahana-Kalman, R., & Goldman, S. (2008). Intermodal matching of emotional expressions in young children with autism. *Research in Autism Spectrum*

Disorders, *2*(2), 301–310. doi:10.1016/j.rasd.2007.07.004

Kampe, K. K., Frith, C. D., Dolan, R. J., & Frith, U. (2001). Reward value of attractiveness and gaze. *Nature*, *413*(6856), 589. doi:10.1038/35098149

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

Kawachi, I., & Berkman, L. F. (2001). Social Ties and Mental Health. *Journal of Urban Health: Bulletin of the New York Academy of Medicine*, *78*(3), 458–467. doi:10.1093/jurban/78.3.458

Kazdin, A. E. (1989). Evaluation of the Pleasure Scale in the assessment of anhedonia in children. *Journal of the American Academy of Child and Adolescent Psychiatry*, *28*(3), 364–372. doi:10.1097/00004583-198905000-00010

Kellerman, J., Lewis, J., & Laird, J. D. (1989). Looking and loving: The effects of mutual gaze on feelings of romantic love. *Journal of Research in Personality*, *23*(2), 145–161. doi:10.1016/0092-6566(89)90020-2

Kim, J. A., Szatmari, P., Bryson, S. E., Streiner, D. L., & Wilson, F. J. (2000). The Prevalence of Anxiety and Mood Problems among Children with Autism and Asperger Syndrome. *Autism*, *4*(2), 117–132. doi:10.1177/1362361300004002002

Klin, A., Jones, W., Schultz, R., & Volkmar, F. (2003). The enactive mind, or from actions to cognition: lessons from autism. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *358*(1430), 345–60. doi:10.1098/rstb.2002.1202

Klin, A., Jones, W., Schultz, R., Volkmar, F., & Cohen, D. (2002). Visual

fixation patterns during viewing of naturalistic social situations as predictors of social competence in individuals with autism. *Archives of General Psychiatry*, *59*(9), 809–16. doi:10.1001/archpsyc.59.9.809

Klin, A., Shultz, S., & Jones, W. (2015). Social visual engagement in infants and toddlers with autism: Early developmental transitions and a model of pathogenesis. *Neuroscience & Biobehavioral Reviews*, *50*(March), 189–203. doi:10.1016/j.neubiorev.2014.10.006

Knoll, L. J., Magis-Weinberg, L., Speekenbrink, M., & Blakemore, S.-J. (2015). Social Influence on Risk Perception During Adolescence. *Psychological Science*. doi:10.1177/0956797615569578

Knutson, B., Westdorp, A., Kaiser, E., & Hommer, D. (2000). FMRI Visualization of Brain Activity during a Monetary Incentive Delay Task. *NeuroImage*, *12*(1), 20–27. doi:10.1006/nimg.2000.0593

Koegel, R. L., & Mentis, M. (1985). MOTIVATION IN CHILDHOOD AUTISM: CAN THEY OR WON'T THEY? *Journal of Child Psychology and Psychiatry*, *26*(2), 185–191. doi:10.1111/j.1469-7610.1985.tb02259.x

Kohls, G., Chevallier, C., Troiani, V., & Schultz, R. T. (2012). Social "wanting" dysfunction in autism: neurobiological underpinnings and treatment implications. *Journal of Neurodevelopmental Disorders*, *4*(1), 10. doi:10.1186/1866-1955-4-10

Kohls, G., Peltzer, J., Herpertz-Dahlmann, B., & Konrad, K. (2009). Differential effects of social and non-social reward on response inhibition in children and adolescents. *Developmental Science*, *12*(4), 614–25. doi:10.1111/j.1467-7687.2009.00816.x

Kohls, G., Peltzer, J., Schulte-Rüther, M., Kamp-Becker, I., Remschmidt, H., Herpertz-Dahlmann, B., & Konrad, K. (2011). Atypical brain responses to reward cues in autism as revealed by event-related potentials. *Journal of Autism and Developmental Disorders*, *41*(11), 1523–33. doi:10.1007/s10803-011-1177-1

Kohls, G., Perino, M. T., Taylor, J. M., Madva, E. N., Cayless, S. J., Troiani, V., … Schultz, R. T. (2013). The nucleus accumbens is involved in both the pursuit of social reward and the avoidance of social punishment. *Neuropsychologia*, *51*(11), 2062–9. doi:10.1016/j.neuropsychologia.2013.07.020

Kohls, G., Schulte-Rüther, M., Nehrkorn, B., Müller, K., Fink, G. R., Kamp-Becker, I., … Konrad, K. (2013). Reward system dysfunction in autism spectrum disorders. *Social Cognitive and Affective Neuroscience*, *8*(5), 565–72. doi:10.1093/scan/nss033

Kovacs, A. M., Teglas, E., & Endress, A. D. (2010). The Social Sense: Susceptibility to Others' Beliefs in Human Infants and Adults. *Science*, *330*(6012), 1830–1834. doi:10.1126/science.1190792

Kringelbach, M. L., & Rolls, E. T. (2003). Neural correlates of rapid reversal learning in a simple model of human social interaction. *NeuroImage*, *20*(2), 1371–1383. doi:10.1016/S1053-8119(03)00393-8

Kuhn, G., Teszka, R., Tenaw, N., & Kingstone, A. (2016). Don't be fooled! Attentional responses to social cues in a face-to-face and video magic trick reveals greater top-down control for overt than covert attention. *Cognition*, *146*, 136–142. doi:10.1016/j.cognition.2015.08.005

Kylliäinen, A., & Hietanen, J. K. (2006). Skin conductance responses to another person's gaze in children with autism. *Journal of Autism and Developmental Disorders*, *36*(4), 517–25. doi:10.1007/s10803-006-0091-4

Kylliäinen, A., Wallace, S., Coutanche, M. N., Leppänen, J. M., Cusack, J., Bailey, A. J., & Hietanen, J. K. (2012). Affective-motivational brain responses to direct gaze in children with autism spectrum disorder. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *53*, 790–797. doi:10.1111/j.1469-7610.2011.02522.x

Lakin, J. L., & Chartrand, T. L. (2003). Using Nonconscious Behavioral Mimicry to Create Affiliation and Rapport. *Psychological Science*, *14*(4), 334–339. doi:10.1111/1467-9280.14481

Lawrence, K., Bernstein, D., Pearson, R., Mandy, W., Campbell, R., & Skuse, D. (2008). Changing abilities in recognition of unfamiliar face photographs through childhood and adolescence: performance on a test of non-verbal immediate memory (Warrington RMF) from 6 to 16 years. *Journal of Neuropsychology*, *2*, 27–45. doi:10.1348/174866407X231074

Lee, S.-H., Booth, J. R., & Chou, T.-L. (2015). Developmental changes in the neural influence of sublexical information on semantic processing. *Neuropsychologia*, *73*, 25–34. doi:10.1016/j.neuropsychologia.2015.05.001

Levinson, C. A., Langer, J. K., & Rodebaugh, T. L. (2013). Reactivity to Exclusion Prospectively Predicts Social Anxiety Symptoms in Young Adults. *Behavior Therapy*, *44*(3), 470–478. doi:10.1016/j.beth.2013.04.007

Levy, S. E., Mandell, D. S., & Schultz, R. T. (2009). Autism. *The Lancet*, *374*(9701), 1627–1638. doi:10.1016/S0140-6736(09)61376-3

Li, J., Zhu, L., Liu, J., & Li, X. (2014). Social and non-social deficits in children with high-functioning autism and their cooperative behaviors. *Research in Autism Spectrum Disorders*, *8*(12), 1657–1671. doi:10.1016/j.rasd.2014.08.016

Libertus, K., & Needham, A. (2011). Reaching experience increases face preference in 3-month-old infants. *Developmental Science*, *14*(6), 1355–1364. doi:10.1111/j.1467-7687.2011.01084.x

Liddle, E. B., Batty, M. J., & Goodman, R. (2009). The Social Aptitudes Scale: an initial validation. *Social Psychiatry and Psychiatric Epidemiology*, *44*(6), 508–513. doi:10.1007/s00127-008-0456-4

Liebal, K., Colombi, C., Rogers, S. J., Warneken, F., & Tomasello, M. (2008). Helping and cooperation in children with autism. *Journal of Autism and Developmental Disorders*, *38*(2), 224–38. doi:10.1007/s10803-007-0381-5

Lin, A., Adolphs, R., & Rangel, A. (2012). Social and monetary reward learning engage overlapping neural substrates. *Social Cognitive and Affective Neuroscience*, *7*(3), 274–81. doi:10.1093/scan/nsr006

Lord, C., Risi, S., Lambrecht, L., Cook, E. H., Leventhal, B. L., DiLavore, P. C., … Rutter, M. (2000). The autism diagnostic observation schedule-generic: a standard measure of social and communication deficits associated with the spectrum of autism. *Journal of Autism and Developmental Disorders*, *30*(3), 205–23. Retrieved from

http://www.ncbi.nlm.nih.gov/pubmed/11055457

Louwerse, A., van der Geest, J. N., Tulen, J. H. M., van der Ende, J., Van Gool, A. R., Verhulst, F. C., & Greaves-Lord, K. (2013). Effects of eye gaze directions of facial images on looking behaviour and autonomic responses in adolescents with autism spectrum disorders. *Research in Autism Spectrum Disorders*, *7*(9), 1043–1053. doi:10.1016/j.rasd.2013.04.013

Loveland, K. A., & Landry, S. H. (1986). Joint attention and language in autism and developmental language delay. *Journal of Autism and Developmental Disorders*, *16*(3), 335–349. doi:10.1007/BF01531663

Macchi Cassia, V., Pisacane, A., & Gava, L. (2012). No own-age bias in 3-year-old children: More evidence for the role of early experience in building face-processing biases. *Journal of Experimental Child Psychology*, *113*, 372–382. doi:10.1016/j.jecp.2012.06.014

Martinsson, P., Nordblom, K., Rützler, D., & Sutter, M. (2011). Social preferences during childhood and the role of gender and age - An experiment in Austria and Sweden. *Economics Letters*, *110*(3), 248–251. doi:10.1016/j.econlet.2010.11.028

Maslow, A. H. (1943). A theory of human motivation. *Psychological Review*, *50*(4), 370–396. doi:10.1037/h0054346

Matson, J. L., & Williams, L. W. (2014). Depression and mood disorders among persons with Autism Spectrum Disorders. *Research in Developmental Disabilities*, *35*(9), 2003–2007. doi:10.1016/j.ridd.2014.04.020

Mazefsky, C. A., Kao, J., & Oswald, D. P. (2011). Preliminary evidence suggesting caution in the use of psychiatric self-report measures with adolescents with high-functioning autism spectrum disorders. *Research in Autism Spectrum Disorders*, *5*, 164–174. doi:10.1016/j.rasd.2010.03.006

McGivern, R. F., Andersen, J., Byrd, D., Mutter, K. L., & Reilly, J. (2002). Cognitive efficiency on a match to sample task decreases at the onset of puberty in children. *Brain and Cognition*, *50*(1), 73–89. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/12372353

Michelson, L., Mannarino, A., Marchione, K., Kazdin, A. E., & Costello, A. (1985). Expectancy bias in behavioral observations of therapeutic outcome: An experimental analysis of treatment and halo effects. *Behaviour Research and Therapy*, *23*(4), 407–414. doi:10.1016/0005-7967(85)90168-8

Millet, K., & Dewitte, S. (2007). Altruistic behavior as a costly signal of general intelligence. *Journal of Research in Personality*, *41*(2), 316–326. doi:10.1016/j.jrp.2006.04.002

Mills, K. L., Lalonde, F., Clasen, L. S., Giedd, J. N., & Blakemore, S.-J. (2014). Developmental changes in the structure of the social brain in late childhood and adolescence. *Social Cognitive and Affective Neuroscience*, *9*, 123–31. doi:10.1093/scan/nss113

Moore, C., Barresi, J., & Thompson, C. (1998). The Cognitive Basis of Future-oriented Prosocial Behavior. *Social Development*, *7*(2), 198–218. doi:10.1111/1467-9507.00062

Moorman, R. H., & Podsakoff, P. M. (1992). A meta-analytic review and empirical test of the potential confounding effects of social desirability response sets in organizational behaviour research. *Journal of Occupational and Organizational Psychology*, *65*, 131–149. doi:10.1111/j.2044-8325.1992.tb00490.x

Morris, J. S., Scott, S. K., & Dolan, R. J. (1999). Saying it with feeling: Neural responses to emotional vocalizations. *Neuropsychologia*, *37*(10), 1155–1163. doi:10.1016/S0028-3932(99)00015-9

Nakano, T., Tanaka, K., Endo, Y., Yamane, Y., Yamamoto, T., Nakano, Y., … Kitazawa, S. (2010). Atypical gaze patterns in children and adults with autism spectrum disorders dissociated from developmental changes in gaze behaviour. *Proceedings. Biological Sciences / The Royal Society*, *277*(1696), 2935–43. doi:10.1098/rspb.2010.0587

Nakayama, H. (2015). Emergence of amae crying in early infancy as a possible social communication tool between infants and mothers. *Infant Behavior and Development*, *40*, 122–130. doi:10.1016/j.infbeh.2015.06.010

Nele, D., Ellen, D., Petra, W., & Herbert, R. (2015). Social information processing in infants at risk for ASD at 5 months of age: The influence of a familiar face and direct gaze on attention allocation. *Research in Autism Spectrum Disorders*, *17*, 95–105. doi:10.1016/j.rasd.2015.06.006

Neumann, D., Spezio, M. L., Piven, J., & Adolphs, R. (2006). Looking you in the mouth: abnormal gaze in autism resulting from impaired top-down modulation of visual attention. *Social Cognitive and Affective Neuroscience*, *1*(3), 194–202. doi:10.1093/scan/nsl030

Nisbett, R. E., & Wilson, T. D. (1977). Telling more than we can know: Verbal reports on mental processes. *Psychological Review*, *84*(3), 231–259. doi:10.1037/0033-295X.84.3.231

Ollendick, T. H., King, N. J., & Frary, R. B. (1989). Fears in children and adolescents: reliability and generalizability across gender, age and nationality. *Behaviour Research and Therapy*, *27*(1), 19–26. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/2914001

Osiński, J. T., Ostaszewski, P., & Karbowski, A. (2014). Social discounting rate is negatively correlated with fluid intelligence. *Personality and Individual Differences*, *59*, 44–49. doi:10.1016/j.paid.2013.10.030

Ozonoff, S., Pennington, B. F., & Rogers, S. J. (1991). Executive function deficits in high-functioning autistic individuals: relationship to theory of mind. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *32*(7), 1081–1105. doi:10.1111/j.1469-7610.1991.tb00351.x

Paal, T., & Bereczkei, T. (2007). Adult theory of mind, cooperation, Machiavellianism: The effect of mindreading on social relations. *Personality and Individual Differences*, *43*(3), 541–551. doi:10.1016/j.paid.2006.12.021

Panasiti, M. S., Puzzo, I., & Chakrabarti, B. (2015). Autistic Traits Moderate the Impact of Reward Learning on Social Behaviour. *Autism Research*, n/a–n/a. doi:10.1002/aur.1523

Park, J., & Baumeister, R. F. (2015a). Social exclusion causes a shift toward prevention motivation. *Journal of Experimental Social Psychology*, *56*, 153–159. doi:10.1016/j.jesp.2014.09.011

Park, J., & Baumeister, R. F. (2015b). Social exclusion causes a shift toward prevention motivation. *Journal of Experimental Social Psychology*, *56*, 153–159. doi:10.1016/j.jesp.2014.09.011

Pauli-Pott, U., & Becker, K. (2011). Neuropsychological basic deficits in preschoolers at risk for ADHD: A meta-analysis. *Clinical Psychology Review*, *31*(4), 626–637. doi:10.1016/j.cpr.2011.02.005

Perner, J., & Lang, B. (2013). *Understanding Other Minds*. (S. Baron-Cohen, M. Lombardo, & H. Tager-Flusberg, Eds.)*Understanding other minds: Perspectives from developmental cognitive neuroscience* (2nd ed.). Oxford: Oxford University Press. doi:10.1093/acprof:oso/9780199692972.001.0001

Peterson, C. (2014). Theory of mind understanding and empathic behavior in children with autism spectrum disorders. *International Journal of Developmental Neuroscience : The Official Journal of the International Society for Developmental Neuroscience*, 1–6. doi:10.1016/j.ijdevneu.2014.05.002

Peterson, C. C., Garnett, M., Kelly, A., & Attwood, T. (2009). Everyday social and conversation applications of theory-of-mind understanding by children with autism-spectrum disorders or typical development. *European Child and Adolescent Psychiatry*, *18*(2), 105–115. doi:10.1007/s00787-008-0711-y

Pfeiffer, U. J., Schilbach, L., Timmermans, B., Kuzmanovic, B., Georgescu, A. L., Bente, G., & Vogeley, K. (2014). Why we interact: On the functional role of the striatum in the subjective experience of social interaction. *NeuroImage*, *101*, 124–137. doi:10.1016/j.neuroimage.2014.06.061

Pierce, K., & Redcay, E. (2008). Fusiform function in children with an autism spectrum disorder is a matter of “who”. *Biological Psychiatry*, *64*(7), 552–60. doi:10.1016/j.biopsych.2008.05.013

Preissler, M. A. (2008). Associative learning of pictures and words by low-functioning children with autism. *Autism : The International Journal of Research and Practice*, *12*(3), 231–48. doi:10.1177/1362361307088753

Raven, J. C., Court, J. H., & Raven, J. C. (2003). *Raven’s Coloured Progressive Matrices*. Peason Education.

Reichow, B., Steiner, A. M., & Volkmar, F. (2012a). Social skills groups for people aged 6 to 21 with autism spectrum disorders (ASD). In B. Reichow (Ed.), *Cochrane Database of Systematic Reviews*. Chichester, UK: John Wiley & Sons, Ltd. doi:10.1002/14651858.CD008511.pub2

Reichow, B., Steiner, A. M., & Volkmar, F. (2012b). Social skills groups for people aged 6 to 21 with autism spectrum disorders (ASD). In B. Reichow (Ed.), *Cochrane Database of Systematic Reviews*. Chichester, UK: John Wiley & Sons, Ltd. doi:10.1002/14651858.CD008511.pub2

Reichow, B., & Volkmar, F. R. (2010). Social Skills Interventions for Individuals with Autism: Evaluation for Evidence-Based Practices within a Best Evidence Synthesis Framework. *Journal of Autism and Developmental Disorders*, *40*(2), 149–166. doi:10.1007/s10803-009-0842-0

Reise, S. P., Horan, W. P., & Blanchard, J. J. (2011). The Challenges of Fitting an Item Response Theory Model to the Social Anhedonia Scale. *Journal of Personality Assessment*, *93*(3), 213–224.

doi:10.1080/00223891.2011.558868

Rekers, Y., Haun, D. B. M., & Tomasello, M. (2011). Children, but not chimpanzees, prefer to collaborate. *Current Biology : CB*, *21*(20), 1756–8. doi:10.1016/j.cub.2011.08.066

Riby, D., & Hancock, P. J. B. (2009). Looking at movies and cartoons: eye-tracking evidence from Williams syndrome and autism. *Journal of Intellectual Disability Research : JIDR*, *53*(2), 169–81. doi:10.1111/j.1365-2788.2008.01142.x

Rinck, M., & Becker, E. S. (2007). Approach and avoidance in fear of spiders. *Journal of Behavior Therapy and Experimental Psychiatry*, *38*(2), 105–120. doi:10.1016/j.jbtep.2006.10.001

Ristic, J., Mottron, L., Friesen, C. K., Iarocci, G., Burack, J. A., & Kingstone, A. (2005). Eyes are special but not for everyone: The case of autism. *Cognitive Brain Research*, *24*(3), 715–718. doi:10.1016/j.cogbrainres.2005.02.007

Ro, T., Russell, C., & Lavie, N. (2001). Changing faces: a detection advantage in the flicker paradigm. *Psychological Science*, *12*(1), 94–9. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/11294237

Ross, P. D., Polson, L., & Grosbras, M.-H. (2012). Developmental changes in emotion recognition from full-light and point-light displays of body movement. *PloS One*, *7*(9), e44815. doi:10.1371/journal.pone.0044815

Russell-Smith, S. N., Bayliss, D. M., & Maybery, M. T. (2013). Unique sets of social and mood characteristics differentiate autistic and negative schizotypy traits in a young adult non-clinical sample. *Personality and*

Individual Differences, *55*(5), 542–546. doi:10.1016/j.paid.2013.04.030

Sasson, N. J., & Touchstone, E. W. (2014). Visual attention to competing social and object images by preschool children with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *44*, 584–592. doi:10.1007/s10803-013-1910-z

Sasson, N. J., Turner-Brown, L. M., Holtzclaw, T. N., Lam, K. S. L., & Bodfish, J. W. (2008). Children with autism demonstrate circumscribed attention during passive viewing of complex social and nonsocial picture arrays. *Autism Research*, *1*(1), 31–42. doi:10.1002/aur.4

Scherf, K. S., Behrmann, M., & Dahl, R. E. (2012). Facing changes and changing faces in adolescence: a new model for investigating adolescent-specific interactions between pubertal, brain and behavioral development. *Developmental Cognitive Neuroscience*, *2*(2), 199–219. doi:10.1016/j.dcn.2011.07.016

Schmitow, C., & Stenberg, G. (2015). What aspects of others' behaviors do infants attend to in live situations? *Infant Behavior and Development*, *40*, 173–182. doi:10.1016/j.infbeh.2015.04.002

Schultz, R. T. (2005). Developmental deficits in social perception in autism: the role of the amygdala and fusiform face area. *International Journal of Developmental Neuroscience : The Official Journal of the International Society for Developmental Neuroscience*, *23*(2-3), 125–41. doi:10.1016/j.ijdevneu.2004.12.012

Schunke, O., Schottle, D., Vettorazzi, E., Brandt, V., Kahl, U., Baumer, T., … Munchau, A. (2015). Mirror me: Imitative responses in adults with autism.

Autism. doi:10.1177/1362361315571757

Scott-Van Zeeland, A. A., Dapretto, M., Ghahremani, D. G., Poldrack, R. A., & Bookheimer, S. Y. (2010). Reward processing in autism. *Autism Research : Official Journal of the International Society for Autism Research*, *3*(2), 53–67. doi:10.1002/aur.122

Sebastian, C. L. (2015). Social cognition in adolescence: Social rejection and theory of mind. *Psicología Educativa*, *21*(2), 125–131. doi:10.1016/j.pse.2015.08.004

Seitz, A. R., Kim, D., & Watanabe, T. (2009). Rewards Evoke Learning of Unconsciously Processed Visual Stimuli in Adult Humans. *Neuron*, *61*(5), 700–707. doi:10.1016/j.neuron.2009.01.016

Seltzer, M. M., Shattuck, P., Abbeduto, L., & Greenberg, J. S. (2004). Trajectory of development in adolescents and adults with autism. *Mental Retardation and Developmental Disabilities Research Reviews*. doi:10.1002/mrdd.20038

Senju, A., & Johnson, M. H. (2009). Atypical eye contact in autism: models, mechanisms and development. *Neuroscience and Biobehavioral Reviews*, *33*(8), 1204–14. doi:10.1016/j.neubiorev.2009.06.001

Senju, A., Southgate, V., White, S., & Frith, U. (2009). Mindblind Eyes: An Absence of Spontaneous Theory of Mind in Asperger Syndrome. *Science*, *325*(5942), 883–885. doi:10.1126/science.1176170

Shamosh, N. A., & Gray, J. R. (2008). Delay discounting and intelligence: A meta-analysis. *Intelligence*, *36*(4), 289–305. doi:10.1016/j.intell.2007.09.004

Shattuck, P. T., Seltzer, M. M., Greenberg, J. S., Orsmond, G. I., Bolt, D., Kring, S., … Lord, C. (2007). Change in autism symptoms and maladaptive behaviors in adolescents and adults with an autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *37*(9), 1735–1747. doi:10.1007/s10803-006-0307-7

Shore, D. M., & Heerey, E. A. (2011). The value of genuine and polite smiles. *Emotion (Washington, D.C.)*, *11*(1), 169–74. doi:10.1037/a0022601

Silva, C., Da Fonseca, D., Esteves, F., & Deruelle, C. (2015). Motivational approach and avoidance in autism spectrum disorder: A comparison between real photographs and cartoons. *Research in Autism Spectrum Disorders*, *17*, 13–24. doi:10.1016/j.rasd.2015.05.004

Sims, T. B., Neufeld, J., Johnstone, T., & Chakrabarti, B. (2014). Autistic traits modulate frontostriatal connectivity during processing of rewarding faces. *Social Cognitive and Affective Neuroscience*, *9*(12), 2010–2016. doi:10.1093/scan/nsu010

Sodian, B., & Kristen, S. (2015). Theory of Mind During Infancy and Early Childhood Across Cultures, Development of. In *International Encyclopedia of the Social & Behavioral Sciences* (pp. 268–273). Elsevier. doi:10.1016/B978-0-08-097086-8.23077-8

Solomon, R. L. (1980). The opponent-process theory of acquired motivation: The costs of pleasure and the benefits of pain. *American Psychologist*, *35*(8), 691–712. doi:10.1037/0003-066X.35.8.691

Speer, L. L., Cook, A. E., McMahon, W. M., & Clark, E. (2007). Face processing in children with autism: effects of stimulus contents and type.

Autism : The International Journal of Research and Practice, *11*(3), 265–77. doi:10.1177/1362361307076925

Spreckelmeyer, K. N., Krach, S., Kohls, G., Rademacher, L., Irmak, A., Konrad, K., … Grunder, G. (2009). Anticipation of monetary and social reward differently activates mesolimbic brain structures in men and women. *Social Cognitive and Affective Neuroscience*, *4*(2), 158–165. doi:10.1093/scan/nsn051

Srivastava, A. K., & Schwartz, C. E. (2014). Intellectual disability and autism spectrum disorders: Causal genes and molecular mechanisms. *Neuroscience & Biobehavioral Reviews*, *46*, 161–174. doi:10.1016/j.neubiorev.2014.02.015

Starr, E., Szatmari, P., Bryson, S., & Zwaigenbaum, L. (2003). Stability and change among high-functioning children with pervasive developmental disorders: A 2-year outcome study. *Journal of Autism and Developmental Disorders*, *33*(1), 15–22. doi:10.1023/A:1022222202970

Stavropoulos, K. K. M., & Carver, L. J. (2014). Reward anticipation and processing of social versus nonsocial stimuli in children with and without autism spectrum disorders. *Journal of Child Psychology and Psychiatry*, *55*(12), 1398–1408. doi:10.1111/jcpp.12270

Tager-Flusberg, H. (2007). Evaluating the Theory-of-Mind Hypothesis of Autism. *Current Directions in Psychological Science*, *16*(6), 311–315. doi:10.1111/j.1467-8721.2007.00527.x

Talwar, V., Murphy, S. M., & Lee, K. (2007). White lie-telling in children for politeness purposes. *International Journal of Behavioral Development*,

31(1), 1–11. doi:10.1177/0165025406073530

Toates, F. (1986). *Motivational systems*. Cambridge Univ. Press, Cambridge (MA).

Todd, J., Mills, C., Wilson, A. D., Plumb, M. S., & Mon-Williams, M. a. (2009). Slow motor responses to visual stimuli of low salience in autism. *Journal of Motor Behavior*, *41*(5), 419–26. doi:10.3200/35-08-042

Tomalski, P., Csibra, G., & Johnson, M. H. (2009). Rapid orienting toward face-like stimuli with gaze-relevant contrast information. *Perception*, *38*(4), 569–578. doi:10.1068/p6137

van den Bos, W., Cohen, M. X., Kahnt, T., & Crone, E. A. (2012). Striatum-Medial Prefrontal Cortex Connectivity Predicts Developmental Changes in Reinforcement Learning. *Cerebral Cortex*, *22*(6), 1247–1255. doi:10.1093/cercor/bhr198

Vetter, N. C., Pilhatsch, M., Weigelt, S., Ripke, S., & Smolka, M. N. (2015). Mid-adolescent neurocognitive development of ignoring and attending emotional stimuli. *Developmental Cognitive Neuroscience*, *14*, 23–31. doi:10.1016/j.dcn.2015.05.001

Wang, A. T., Lee, S. S., Sigman, M., & Dapretto, M. (2007). Reading Affect in the Face and Voice. *Archives of General Psychiatry*, *64*(6), 698. doi:10.1001/archpsyc.64.6.698

Watson, K. K., Miller, S., Hannah, E., Kovac, M., Damiano, C. R., Sabatino-DiCrisco, A., … Dichter, G. S. (2015). Increased reward value of non-social stimuli in children and adolescents with autism. *Frontiers in Psychology*, *6*. doi:10.3389/fpsyg.2015.01026

Wechsler, D. (2011). *Manual Intelligence Scale Wechsler Adult*. (D. Wechsler, Ed.) (4th ed.). Publishing Centre of Applied Psychology, Paris.

Weil, L. G., Fleming, S. M., Dumontheil, I., Kilford, E. J., Weil, R. S., Rees, G., … Blakemore, S.-J. (2013). The development of metacognitive ability in adolescence. *Consciousness and Cognition*, *22*(1), 264–271. doi:10.1016/j.concog.2013.01.004

White, S. J. (2013). The Triple I Hypothesis: taking another('s) perspective on executive dysfunction in autism. *Journal of Autism and Developmental Disorders*, *43*(1), 114–21. doi:10.1007/s10803-012-1550-8

Williams, K. S., Yeager, D. S., Cheung, C. K. T., & Choi, W. (2012). Cyberball [Software]. Retrieved from https://cyberball.wikispaces.com

Wilson, C. E., Brock, J., & Palermo, R. (2010). Attention to social stimuli and facial identity recognition skills in autism spectrum disorder. *Journal of Intellectual Disability Research : JIDR*, *54*(12), 1104–15. doi:10.1111/j.1365-2788.2010.01340.x

Wilson, T. D., Reinhard, D. A., Westgate, E. C., Gilbert, D. T., Ellerbeck, N., Hahn, C., … Shaked, A. (2014). Just think: The challenges of the disengaged mind. *Science*, *345*(6192), 75–77. doi:10.1126/science.1250830

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*(1), 11–29. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/155684

Wolf, L. K., Bazargani, N., Kilford, E. J., Dumontheil, I., & Blakemore, S.-J.

(2015). The audience effect in adolescence depends on who's looking over your shoulder. *Journal of Adolescence*, *43*(29), 5–14. doi:10.1016/j.adolescence.2015.05.003

World Health Organisation. (1992). *The ICD-10 Classification of Mental and Behavioural Disorders*. Geneva: World Health Organization.

Yarbus, A. L. (1967). *Eye movements and Vision*. (L. A. Riggs, Ed.). New York: Plenum Press. Retrieved from http://wexler.free.fr/library/files/yarbus (1967) eye movements and vision.pdf

Zellner, D. A., Allen, D., Henley, M., & Parker, S. (2006). Hedonic contrast and condensation: good stimuli make mediocre stimuli less good and less different. *Psychonomic Bulletin & Review*, *13*(2), 235–239. doi:10.3758/BF03193836

Zhong, C.-B. (2011). The Ethical Dangers of Deliberative Decision Making. *Administrative Science Quarterly*. doi:10.2189/asqu.2011.56.1.001