Abstract

The aim of this thesis was to investigate the retrodictive mentalising abilities (a kind of backwards inference from a mental state to its causal antecedent in order to make sense of others' behaviours) of people with and without Autism Spectrum Disorder (ASD). A new experimental paradigm was developed in order to examine people's ability to make sense of others' behaviours in a way that closely resembles the intricacies of real-world settings. The stimuli utilised in this thesis portrayed people's spontaneous and genuine responses during four specific events (scenarios). People were told a joke in the Joke scenario whereas in the Story scenario the researcher related a series of unfortunate mishaps that she experienced earlier in the day. In the Compliments scenario, people were told a series of compliments while in the Waiting scenario the researcher performed irrelevant tasks during an experiment whilst the person was kept waiting. Participants viewed brief videoclips of these behavioural responses and were asked to determine which event had previously occurred to the people in the videoclips. Participants eye movements were recorded to ascertain the visual strategies used. Typically developing individuals successfully inferred the events that occurred by viewing brief samples of behavioural reactions of typically developing individuals (Experiment 1). It was found that scenario experienced did not impact how targets self-reported their level of empathic ability (Experiment 2). While people with ASD were able to infer people's behavioural responses, their performance on the task was inferior as compared to typically developing individuals (Experiment 3). Participants varied their gaze strategies depending on the event experienced by the people in the videoclips and they had a tendency to focus more on the mouth compared to the eye region of the face (Experiment 1 and 3). When participants viewed videoclips of behavioural responses of people with and without ASD to the same events, they were more successful at inferring the

reactions to the events which occurred when viewing videoclips of neurotypical individuals as opposed to individuals with ASD (Experiment 4). Furthermore, participants were unable to identify the reactions to two of the four events when viewing videoclips of people with ASD.

List of Papers

Pillai, D., Sheppard, E., & Mitchell, P. (2012). Can People Guess What Happened to Others from Their Reactions? *PLoS ONE*, *7*(11), e49859. doi:10.1371/journal.pone.0049859

- Experiment 1 in this thesis was based on the above manuscript along with some additional data.

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- Experiment 3 in this thesis was based on the above manuscript along with some additional information.

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Retrodictive Mentalising Abilities of Individuals With and Without Autism Spectrum Disorder

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CHAPTER 1

Mentalising

1.1 The origins and development of mentalising

The problem of other minds is an epistemological issue concerning how we can know that there are minds other than our own. People directly experience their own minds from a first-person subjective perspective, allowing direct access to feelings and beliefs. In contrast, interpreting and understanding another mind is something we can only do by making inference from clues in external, observable behaviour. The connection between the mental and physical worlds has been questioned by philosophers and scientists for centuries, often being termed the 'mind-body' problem. The early modern philosopher Descartes coined the term substance-dualism which states that the mind and the body are distinct elements with independent existence. The body encompasses space and does not have thought. On the other hand, thought is the core feature of the mind, without an extension in the physical world. Substance-dualism presents a challenge for understanding of others' minds; if the mind and body are separate entities, how can we make inferences about the mind from clues in behaviour? Being able to make such inferences implies that, contrary to the view expressed by Descartes, the mind has physical embodiment or at the very least a physical counterpart. Although bodily expressions can be perceived, it is fair to assume that the individual has better knowledge of his/her own mind compared with a mere observer, for the individual has first-person subjective access to his/her own inner states.

Nevertheless, because others' bodies and behaviours are visibly similar to one's own body and behaviours, it is fair to assume that they too have thoughts and feelings. However this simplistic reasoning is an overgeneralisation due to its use of induction (Lacewing, 2009). While deductive reasoning uses generalisations to reach certain conclusions, inductive reasoning on the other hand uses specific observations to formulate generalisations. As such the inferences made from inductive reasoning are probable rather than conclusive (hence we can only suppose that it is probable but not definite that others have minds). Furthermore, the prominent philosopher Wittgenstein's take on the mind-body problem was that philosophy (i.e. mind) and science (i.e. body) are different 'languages' which cannot be compared or questioned on the same plane.

The philosophy of mind debate has evolved from focus on understanding sensations such as pain to the understanding of social communication skills and psychological states such as emotions and beliefs. Barresi and Moore (1996) suggested that "the evolution of intelligence in primates that ultimately led to human beings was driven in part by the demands of social information processing". Hence the significance of social communication has been a key research area in recent years.

There is much value in describing behaviours in mentalistic terms as it potentially offers explanatory and predictive significance. Daniel Dennett is a key philosopher who brought together the disciplines of philosophy and developmental psychology. He suggested the use of mental concepts as a viewpoint exclusive to specific kinds of complex behaviours. Dennett's prominent idea is that one is able to mindread another person by 'rationalisation', using what he called the *intentional stance*. The primary use of intentional stance is to ascribe beliefs to a system for the purpose of predicting its future behaviour. `Intentional systems are, by definition, all and only those entities whose behaviour is predictable/explicable from the intentional stance' (Dennett, 1996, p. 34). It was proposed that the intentional stance is a functional approach in order to predict the behaviours and actions of human beings, plants, monkeys, along with various other systems to which intentions are not typically attributed (Dennett, 1987).

With that in mind; imagine seeing a woman walking towards the cashier in a grocery store and then stopping and looking through her handbag. One could assume that she is searching for her purse. This interpretation is made possible by drawing upon one's intentional understanding abilities. In developmental psychology, this process of assigning mental states to oneself and others is known as 'theory of mind' (Astington, Harris, & Olson, 1988). Premack and Woodruff (1978) initially devised this term in order to highlight the indiscernible nature of mental states. Throughout the years, 'theory of mind' has been used interchangeably with other terms such as 'mentalising', 'intentional stance' and 'mindreading'. The term *mentalising* will be used in this dissertation as it widely encompasses relevant aspects associated with the subject matter. In the paper titled "Does the chimpanzee have a theory of mind?", Premack and Woodruff (1978) essentially questioned the ability of the mind of the chimpanzee to function like a human mind, with the abilities to make suppositions that the behaviours and actions of others are established by their attitudes, desires and beliefs. Their ground-breaking research included several studies which investigated whether chimpanzees implicitly knew that others have different thoughts and mental states. In one experiment, Premack and Woodruff (1978) showed a chimpanzee video-recordings of an actor experiencing certain difficulties (e.g., reaching for bananas hung from a ceiling or trying to escape from a cage). These videos were stopped before the actor in the video-recording found a solution to the problem. The chimpanzee was then shown two pictures in which only one portrayed the actor solving the problem previously depicted. It was found that the chimpanzee reliably picked the picture of the actor solving the problem, implying that the chimpanzee ascribed mental states to the actor. However some critics (e.g. Savage-Rumbaugh & Rumbaugh, 1979) have suggested that the chimpanzee might have simply linked familiar behaviours and consequences. Compared to the ambiguity surrounding mentalising abilities in nonhumans, the development of these abilities in humans is presumed to be somewhat natural. A key question that arises about the development of this undoubtedly proficient ability is; how and when does this skill develop?

Dennett's (1978) commentary on Premack and Woodruff's paper further fuelled the debate around the 'mind-readers' or 'behaviour-readers' paradigm. He proposed several ideas for future research in order to make a clearer distinction between the two abovementioned groups. Dennett contended that an unequivocal test of mental state ascription calls for the chimpanzee to predict that the actor would engage in an incorrect behaviour. A measure of false-belief attribution in essence was what Dennett stated was lacking in Premack and Woodruff's study. Dennett offered a recommendation around this issue based on the popular puppet show characters, Punch and Judy. He proposed a scenario in which Punch has an incorrect belief about Judy's location; would observing children be able to predict Punch's incorrect and fruitless search for Judy? If so, then they have an understanding of false belief and should be duly credited with a theory of mind. This is because in order to understand that a mind can represent, one must appreciate that it can *misrepresent* (i.e. hold a false belief) and will consequently have an impact on the attributor's behaviours in a way that will determine the actor's behaviour (Griffin & Baron-Cohen, 2002). Additionally, the need to inhibit one's natural inclination to ascribe a true belief make false belief tasks more difficult than straightforward true belief tasks (Roth & Leslie, 1998).

Thus began the onset of mentalising research, initiated by Wimmer and Perner (1983). Inspired by Dennett, they devised the classic 'unexpected-transfer test' where children are told a story of a child named Max (see Figure 1.1). Max puts a bar of chocolate in the green cupboard then goes out to play. In his absence, Max's mother moves the chocolate from the green cupboard to the blue cupboard. The child is asked where Max will look for his chocolate when he returns back home. In order to successfully pass this task, the child must understand that another person (in this case, Max) can have a false representation of the world. The findings revealed that none of the 3 to

4 year-olds were able to accurately state where Max would look for his chocolate (all children stated that Max would look in the blue cupboard) while 57% of the 4 to 6 year-olds responded accurately. Almost all the 6 to 9 year-olds correctly pointed to green cupboard. The success in this task necessitates the understanding that other people's beliefs may differ from one's own as well as to envisage how others will respond based on their different beliefs.

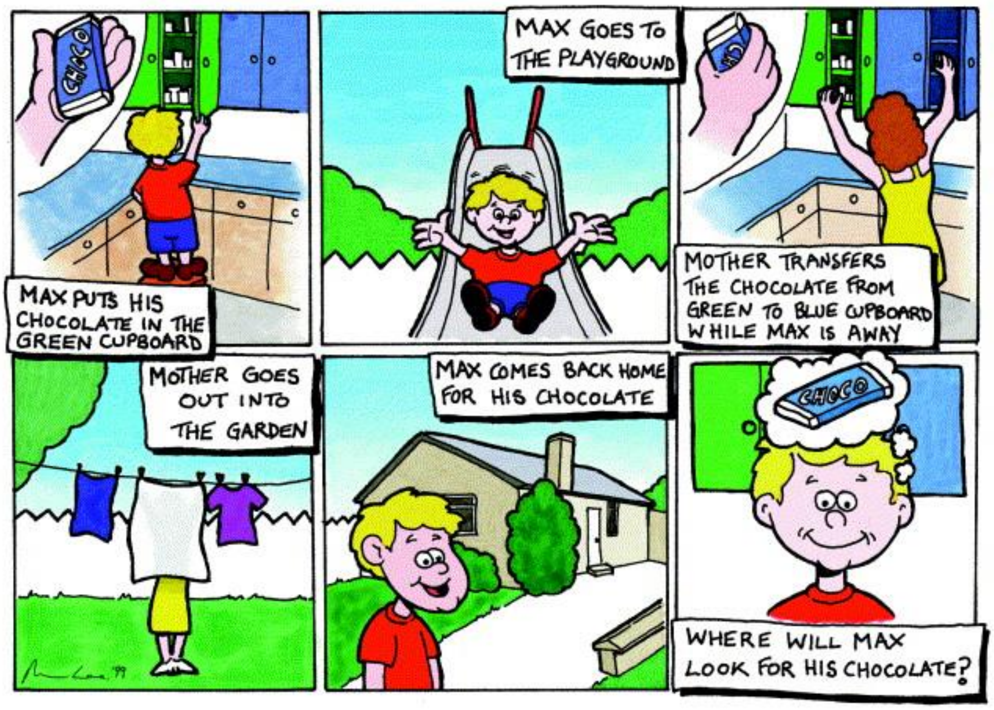

Figure 1.1: The chocolate story (adapted from Perner & Lang, 1999).

The 'unexpected contents task' is another false belief task which was devised as an alternative to the 'unexpected transfer task' to reduce the demands of advanced language skills required (Hogrefe, Wimmer, & Perner, 1986) (see Figure 1.2). The children are shown a candy container with an unanticipated item inside (e.g., crayon). The children are then asked what they initially thought was inside the container as well as what someone else may think is inside the candy container. The findings revealed that 3-year-olds did not understand that only the person who had previously looked inside the container is aware of the true contents of the container.

Additionally the 3-year-olds even failed to acknowledge their own prior false beliefs about the contents of the candy container. Both the 'unexpected transfer' and 'unexpected contents' tasks are known as first-order mentalising tasks (Baron-Cohen, 2000).

Figure 1.2: An illustration of the unexpected contents task (adapted from www.autismservice.org).

A meta-analysis of 178 false belief studies found that the age at which 50% of children are able to pass false belief tasks is 3 years, 8 months (Wellman, Cross, & Watson, 2001). They stated that younger children's failure of the false-belief tasks was due to a lack of conceptual understanding suggesting that performance in false-belief tasks reflect the developmental trajectory and the actual changes in children's conception of others. They stated that as age increased, children's performance on false-belief tasks progressed from incorrect to significantly correct on both easy and more complex tasks. In general, researchers who believe in the radical conceptual shift claim that at approximately 4 years of age a conceptual change occurs where children are able to comprehend and predict the behaviours of others by attributing mental states to them (e.g., Saxe, Carey, & Kanwisher, 2004).

Researchers then developed more complex false-belief tasks to assess older children with more superior mentalising abilities. This was done so as to evaluate children's progression of false belief understanding with increased age and task difficulty. Second-order mentalising tasks were designed to tap into one's ability to attribute a belief about another person's belief (Baron-Cohen, 2000; Perner & Wimmer, 1985). Second-order mentalising abilities is developed at approximately seven years of age, whereupon children are capable of knowing that another person understands something about someone or something else (Baron-Cohen, Leslie, & Frith, 1985). Mentalising abilities evidently progress with age (beyond the benchmark notions of desire, intention and belief) as children begin to acquire a better understanding of faux pas (Baron-Cohen, O'Riordan, Stone, Jones, & Plaisted, 1999), social deception such as white lies (Happé, 1994) as well as the understanding of sarcasm, metaphor and irony (Happé, 1994).

It has been established that children's ability to pass false belief tests emerges at about age four (e.g., Gopnik & Astington, 1988) even across different cultures (Callaghan et al., 2005) and henceforth continues to advance. However does this imply that children below the age of four have no understanding of others' mental states? It has been shown that prior to being able to pass a false belief task, infants have the ability to predict others' actions and preferences (Meltzoff, 1995). Furthermore, studies have found that infants as young as seven months may have the capability of thinking about someone else's mental states and false beliefs (Baillargeon, Scott, & He, 2010; Kovács, Téglás, & Endress, 2010). Other researchers have found evidence of infants and toddlers between the ages of 13 to 25 months showing low-level mentalising abilities in tasks involving false beliefs about location and/or identity, as well as false perceptions using violation-of-expectation (VOE) and anticipatory-looking (AL) models of testing (Onishi & Baillargeon, 2005; Southgate, Senju, & Csibra, 2007; Surian, Caldi, & Sperber, 2007). In Onishi and Baillargeon's (2005) nonverbal task, 15-month-old infants were shown videos of a toy being hidden while the actor watched. Then the toy is moved to another location, unknown to the actor as his view was blocked by a partition. The findings revealed that when the partition was removed, infants looked longer at the original rather than the current location of the toy. This seems to demonstrate that the children's gaze pattern reflected their anticipation of the actor's behaviour based on the actor's belief and not their own belief. This finding was also replicated among two-year-olds in Southgate et al. (2007). Nonetheless these findings have been challenged by contentions that the infants and toddlers merely used either a behavioural rules system (Penn & Povinelli, 2007) or a 'person-object-location' association (Perner & Ruffman, 2005).

On the other hand, Apperly and Butterfill (2009) proposed that there are two 'mindreading systems' to account for the discrepancies in the literature in regards to infants' ability to pass false belief tasks contrasting with the later development of false belief understanding at age four. They hypothesised that the first approach consists of a low-level system which functions efficiently, automatically and is inflexible (e.g. a primitive system for tracking belief-like states which guides children's gaze behaviour). The second system supposedly operates at a high-level, is more flexible but is less efficient due to its demands on executive systems such as working memory and cognitive control (e.g. an advanced system which supports children's explicit appraisals about beliefs.) Though the literature is mixed between findings of false-belief abilities appearing before age four (Chandler, Fritz, & Hala, 1989) and others reporting the emergence after age four (Gopnik & Wellman, 1992), the findings reveal that the ability to implicitly attribute false beliefs to others may be present by the age of two years. Moreover the capacity to ascribe false beliefs is said to be one of many antecedents in developing full-fledged mentalising abilities. Hence the next question to ask is what are the other building blocks that contribute to the development of mentalising abilities?

Studies have shown that children below the age of three start to develop various socio-cognitive abilities vital for grasping future mental state understanding. Csibra, Gergely, Bíró, Koós, and Brockbank (1999) found support for nine to 12 month old infants being able to perceive another's action as goal oriented. Callaghan et al. (2005) reported pretend play, joint attention, awareness of intentional actions, and imitation as some of the building blocks of mentalising abilities. Tomasello and Haberl (2003) investigated 12 and 18 month old infants and found that infants of both ages demonstrated understanding of others as intentional and attentional agents. It was found that 13-month olds have the ability to attribute a false belief to another person about the location of an object (Surian et al., 2007). Findings from Song and Baillargeon's (2008) study illustrated that 14.5 month old infants could attribute to another person a false perception of an object. Furthermore, perspective taking abilities have been found to emerge within the first 18 months of life (Sodian, Thoermer, & Metz, 2007). Similarly, Carpenter, Nagell, and Tomasello (1998) reported that infants begin to share the experience of focusing on something with others by nine months of age. Infants tend to naturally follow another person's gaze as if attending to that person's point of interest. Related to the concept of joint attention, social referencing (i.e. when infants assess their mother's expression before moving towards or away from a novel object) has also been associated with development of mentalising ability (Repacholi, 1998). In their study, Carpenter et al. (1998) also showed that infants imitated purposeful and not accidental actions, which suggests that they are able to make a distinction between someone's intention and their action (Gergely, Bekkering, & Király, 2002). During the second year of life, children begin to engage in pretend play where a child decouples reality ('a nonliving doll') from a pretend state ('my baby'), which denotes the presence of meta-representation (Leslie, 1994). There also has been some evidence supporting the understanding of emotions, desires and perception in two-year-olds (Wellman, Phillips, & Rodriguez, 2000). The above mentioned components among others play a vital role for further advancement in mental state reasoning.

Perspective taking abilities are another precursor related to mentalising development (Flavell, 2004). For example, consider the understanding needed to grasp that a piece of paper laid flat on a table will appear differently to the people seated around the table. Children also show the understanding about desire at around age two as they seem to understand and reason non-egocentrically that people's preferences, emotions and attitudes about things around them can be used to predict their future behaviours (Wellman et al., 2001).

Language development is also thought to assist in the advancement of later mentalising abilities (e.g., pragmatics- the appropriate use of language in social settings; Farrar & Maag, 2002). Farrar and Maag (2002) found strong links between early language development and later theory of mind performance in typically developing children. Furthermore, children begin to acquire emotional understanding at a young age. Studies have shown that important changes take place between the ages of three to five (Wellman, Cross, & Watson, 2001). Three-year olds generally are able to identify basic emotions and can comprehend that others may experience different emotions compared to themselves in similar situations (Denham et al., 2003). By the age of four, children have an understanding that beliefs and desires are private and variable entities (Frith & Frith, 2003). Most typically developing children pass the first-order Max-chocolate task by the age of four (Wimmer & Perner, 1983). A second-order belief task developed by Sullivan, Zaitchik, and Tager-Flusberg (1994) consisted of person A not being updated about person B's newly learned information. Their findings revealed that children over the age of five were able to pass this task. Tests were then developed to assess advanced levels of mentalising such as the Strange Stories Task (Happé, 1994), Faux Pas Test (Baron-Cohen, O'Riordan, Stone, Jones, & Plaisted, 1999) and more recently the Meta Photograph Test (Egeth & Kurzban, 2009).

The various components mentioned above (among others) all play a role in the formation and progression of the multifaceted mentalising sphere. Furthermore, there are striking similarities between the building blocks of mentalising abilities and their close relationship to overall successful social communication abilities. In consequence, these building blocks play a vital role in social functioning as we learn about the world around us in mentalistic terms.

As previously mentioned, research suggests that one's mentalising abilities gradually progress with age extending to more advanced levels of proficiency from preschool to young adulthood (Maylor, Moulson, Muncer, & Taylor, 2002). Literature in regards to mentalising proficiency in adulthood is varied. Some studies have found no differences between younger and older adults in mentalising story comprehension tasks (Keightley, Winocur, Burianova, Hongwanishkul, & Grady, 2006) while Slessor, Phillips, and Bull (2007) reported that older adults generally performed rather poorly in mentalising tasks as compared to their younger counterparts. Though still debatable, much research has shown that people's mentalising abilities tend to decline from younger to older adulthood, irrespective of age-related changes of cognitive functioning such as processing speed and memory (Bernstein, Thornton, & Sommerville, 2011).

1.2 Theories of mentalising

1.2.1 Theory-theory

Theory-theory is an account of the development of children's understanding of the mind which states that it originates from innate 'naïve' abilities that form the foundation of the theories of mind which the child creates (Meltzoff, 1999). This theory postulates that as the child learns and experiences new things (i.e. from the environment and people around), he/she continues to build upon and modify existing theories (Gopnik & Wellman, 1992). Accordingly, theory-theory has also been known as the ‘child scientist’ theory as the structure in which theories are formed seems somewhat scientific in manner: information is acquired, hypotheses made and tested, and subsequent revision of the theory occurs if hypotheses are not supported, ranging from simple to more complex theories. Social environment plays a large role in mentalising development according to theory-theory, as a child who experiences an enriched and diverse social environment will acquire mentalising skills faster than a child from a less enhanced background (Gopnik & Wellman, 1994). Due to the heavy influence of environment on mentalising progression, Hughes and Leekam (2004) noted that there could be cultural differences in children’s understanding of mental states. On the whole, theory-theory was a prominent account of mental state development in the 90’s; however the ‘conceptual deficit’ paradigm was heavily challenged when new methods of investigating false belief understanding in younger children revealed that even 15 month-olds were able to pass nonverbal false belief tasks (Onishi & Baillargeon, 2005). This paints a picture of mental state reasoning much earlier than that proposed by theory-theory.

1.2.2 Modularity theory

Proponents of modularity theory suggest that mentalising is a central and inherent biological ability composed of modules which ‘mature’ over time, hence age is a critical feature and social experiences on the other hand, play a smaller role in its development (Leslie, 1987) . These modules are made up of domain-specific frameworks (i.e. to be used in limited areas and restricted contexts) as opposed to a domain-general structure (i.e. can be used to solve problems in various subject matter and contexts) proposed in theory-theory. Though these modules are triggered by the environment, the environment in itself does not control or modify the maturation process of mentalising abilities (Baron-Cohen, 1989; Leslie, 1987). Leslie (1994) proposed three main modules involved in the maturation process. The first module is *Theory of Body* which develops in the first year of life. At this stage, infants learn to understand and recognise that people have an internal mechanism that enables them to move on their own i.e. mechanical agency. Then he described the *Theory of Mind Mechanism* which emerges in two phases which make up the second and third modules. The first phase of *Theory of Mind Mechanism* explains events in terms of goals and intentions i.e. actional agency. This stage is often characterised by attention to eye gaze. Then the third module (i.e. second phase of *Theory of Mind Mechanism*) describes events in terms of propositional attitudes and beliefs i.e. attitudinal agency. Flavell (1999) defined propositional attitudes as mental states such as 'believing that, imagining that, pretending that, and desiring that'. As such the third module is essential for the understanding that other people can hold beliefs that differ from our own.

1.2.3 Simulation theory

Another account of the development of mentalising ability is called simulation theory. The basic premise of simulation theory is that mentalising ability develops when an individual is able to simulate what he or she thinks another person's thoughts, feelings or behaviours might be. Perner and Howes (1992) pointed out that the concept of simulation can be related back to Piaget's view on perspective-taking. Among those who have championed simulation theory are Robert Gordon, Alvin Goldman, Jane Heal and Paul Harris. "What would I do if I were in that person's situation?"- Gordon (1986) proposed that individuals predict the behaviours of others by answering the above question. He states that simulation requires not just a 'transfer', rather a 'transformation', implying that when person A simulates person B, person A 'transforms' to person B during simulation. Goldman (1989) on the other hand, suggested that mentalising occurs when individuals 'simulate' another person by attempting to form comparable mental states in order to represent the mental state of the other person in question. The individual then utilises these new representations to create more mental states, some of which would be attributed to the other person. In essence, Goldman's view postulates that people ascribe mental states by acting as if being in the other person's shoes. Proponents of simulation theory suggest that abilities required to 'simulate' others are influenced by one's own social experiences (e.g. Harris, 1992). Though there are several versions of simulation theory, all concur in presenting it is a valuable heuristic mechanism with predictive and explanatory function.

1.2.4 Mirroring and simulation mentalising

Mirror systems were first discovered in macaque monkeys (Rizzolatti, Fadiga, Gallese, & Fogassi, 1996) and subsequently in humans (Rizzolatti & Craighero, 2004). Mirroring systems have been associated with imitation and empathy (Iacoboni & Dapretto, 2006), evolution of language (Giacomo Rizzolatti & Arbib, 1998) as well as the facilitation of mentalising skills (Gallese & Goldman, 1998). Additionally, mirroring processes have been found in areas such as emotion and perception (Keysers & Gazzola, 2006).

In the macaque monkey, mirror neurons were discovered in the prefrontal cortex and activated when engaged in a goal oriented action such as grasping (Rizzolatti et al., 1996). The neurons are also activated when the macaque observes another monkey or human performing the same action. In other words, the attributor 'mirrors' an action in his or her brain similar to what is perceived of the target's action. Hence, researchers have suggested that mirror neurons provide the foundation for people's ability to simulate and understand the mental states of others.

Gallese and Goldman (1998) stated that mirror neurons may function as a mechanism to detect mental states of others, hence possibly acting as a precursor or being a part of overall mentalising capabilities. Wicker et al. (2003) demonstrated a case of mentalising (via face processing) of disgust. They conducted an fMRI study in which participants first viewed videoclips of people smelling the contents of a glass (disgusting, pleasant, neutral) and subsequently displaying the relevant facial expressions. Then the participants inhaled rancid, pleasant and neutral odours through a mask. The results of the study revealed that the same areas in the brain (i.e. anterior insula and anterior cingulate cortex) were activated during both the video observation of disgusted facial affect and during the smelling of the rancid odour. The authors conclude that just as watching others' motor movements (such as hand actions) activates one's own representation of the action, the same can be applied when observing an emotion as the neural instantiation of that emotion is activated in the observer's mind (see Figure 1.3 for an example of mentalising and disgust).

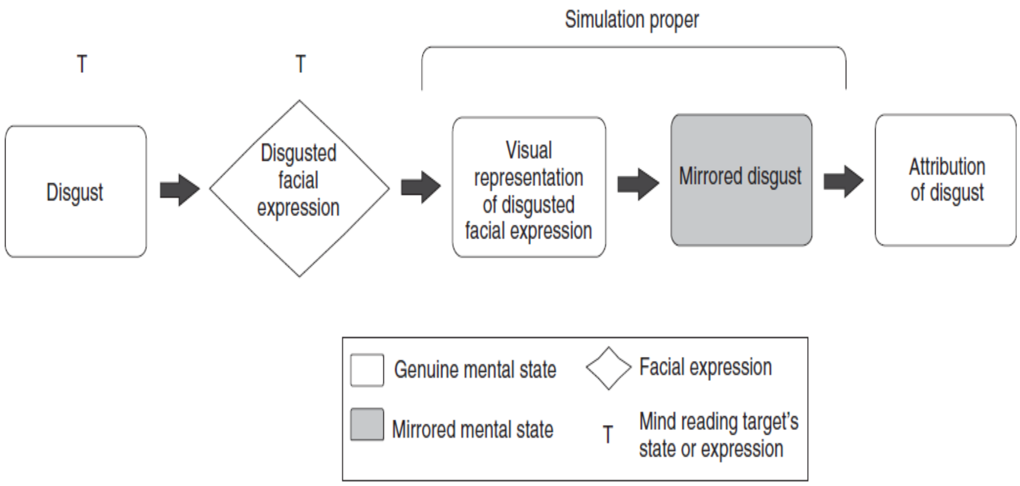

Figure 1.3: An example of simulation and low-level (face-based) mentalising of disgust (adapted from Shanton & Goldman, 2010).

Gallese & Goldman (1998) also state that this type of simulation can be used to retrodict and predict others' mental states. Retrodiction means that people work backwards to make an inference about a prior mental state based on currently observed behaviour. Similarly, people may utilise the same processes in order to predict someone's future behaviours. In the same line of thought, the 'reverse simulation' heuristic was developed by Goldman and Sripada (2005); a process in which the attributor processes the relevant emotional responses in the reverse direction. Gallese (2003) noted that basic mirror simulation is often ‘automatic, unconscious, and pre-reflexive’ and involves the attribution of simple mental states (e.g., those associated with facial expressions such as disgust, happiness and fear). If mirroring processes are utilised in mentalising, there should be consequences in the form of intention attribution and not just the prediction of actions or direct mimicry (Goldman, 2009). In other words, simply mirroring someone else’s emotional state, for instance, does not reflect upon actual emotion attribution of the particular state. Rather mirroring processes may be viewed as one of the starting points of assigning attribution. Iacoboni et al. (2005) conducted a study using fMRI to investigate people’s intention and prediction of future action. Twenty-three participants were presented with three kinds of video stimuli: *action videoclips* (grasping hand action on a teacup); *context videoclips* (only objects prepared for tea); and the *intention videoclips* (grasping hand action on a teacup within the during-tea or post-tea conditions). After imaging data was collected, participants were debriefed about the videoclips they watched. Participants subsequently reported the intention of drinking when observing grasping behaviour in the during-tea condition, while they reported the intent to clean-up when observing the grasping behaviour in the post-tea condition. Furthermore, only the *intention videoclips* produced increased activation in participants’ premotor mirror neuron systems. These findings demonstrated that whilst mirroring processes are being utilised, intentional attributions were being made, and not mere imitation or action prediction. Hence, low-level mentalising could be viewed as an expansion of basic automatic behavioural and mental mimicry processes, both essential components of social cognition (Goldman, 2012).

1.2.5 Simulation and high-level mentalising

Arguably, low-level mentalising is composed of basic mirroring simulation processes; however not all mentalising processes can be explained by mirroring strategies. High-level mentalising, on the other hand, is more complex and often includes propositional attitudes. It is also said to be relatively slower, introspective and controlled (Goldman, 2012). In addition high-level mentalising generally works with the support of known prior knowledge (Shanton & Goldman, 2010). The general notion of mental simulation lies upon the attributor trying to 're-experience' a certain mental event (Goldman, 2009). Subsequently, Goldman (2012) proposed a concept he termed 'enactment imagination' which encapsulates the notion of mental pretense. According to him, enactment imagination assists in generating in one's mind a mental state that is not explicitly observable. Shanton and Goldman (2010) provided a comprehensive example of how imagination may be used in a more complex context of mentalising (also refer to Figure 1.4).

> If you seek to predict someone's decision—for example, the choice of a main dish by your dinner companion at a restaurant—how could you use imagination to make this prediction? The first step is to put yourself in your target's shoes, or take her 'perspective'. Taking someone's perspective here means adopting, as far as feasible and in light of what you know about her, the mental states she starts with. This includes her preferences about food in general, what she liked at this restaurant on previous occasions, how hungry she is on the present occasion (did she have a light lunch, no lunch, or a heavy lunch today?), and so forth. Using the imagination, you can simulate being in her various dinner-relevant states. Such pretend states can then be fed into your decision-making mechanism, which generates a decision to order a particular main dish. Having used this simulation process to generate a (pretend) choice, you don't order this dish yourself but attribute the choice to your companion (p. 31).

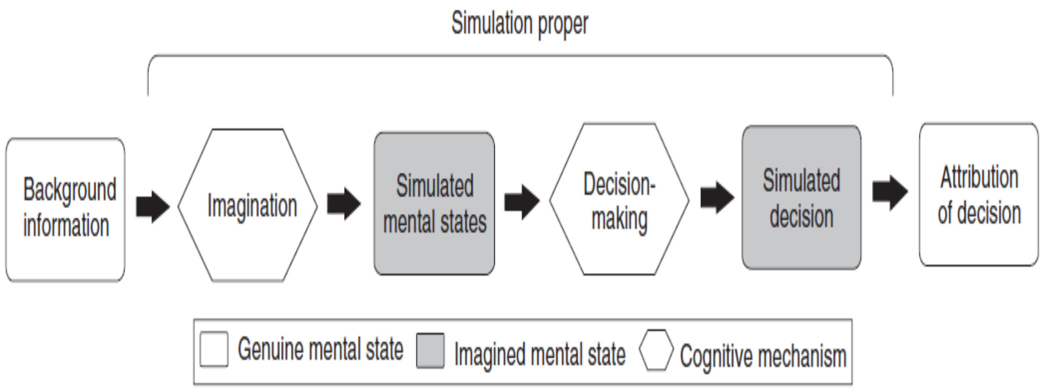

Figure 1.4: An example of attribution based on imagination driven simulation (adapted from Shanton & Goldman, 2010).

Based on the example provided above, the difference between mirroring and enactment imagination is evident. Mirroring involves the automatic re-enactment in the attributor's mind of another person's experience. On the other hand, in enactment imagination, one endeavours to re-create the experience devoid of direct observation of the other person. Therefore, enactment imagination may be effectively utilised to read others' minds. An apparent overlap of theory-theory and simulation theory principles are present in the abovementioned high-level mentalising processes, creating a 'hybrid' approach (Goldman, 2006).

1.3 Mental state recognition

1.3.1 Emotion recognition

The classic study carried out by Ekman and Friesen (1971) demonstrated the presence of six universally identified basic emotions- happy, sad, angry, fear, disgust, and surprise (see Figure 1.5). Infants as young as four months are able to distinguish several basic facial expressions such as happiness and sadness (Serrano, Iglesias, & Loeches, 1992), and their ability to accurately identify emotional facial expressions progresses with age. According to Felleman, Carlson, Christopher, Rosenberg, and Masters (1983) children are able to identify all basic emotions by the age of five but it is not until adolescence that the ability is fully developed (Gao & Maurer, 2010; Tonks, Williams, Frampton, Yates, & Slater, 2007).

Figure 1.5: The six basic emotions adapted from Ekman & Friesen (1971). (from top left: anger, fear, disgust, surprised, happiness and sadness)

It is widely known that emotions are often initiated by some sort of social experience (Salovey, 2003) and that these social experiences influence the way in which emotions are formed and vice versa (Parkinson, Fischer, & Manstead, 2004). The connection between the social world and emotions are manifold; researchers have found evidence for a subset of emotions now termed social emotions (Hareli & Weiner, 2002). Embarrassment (see Figure 1.6), shame and jealousy are examples of social emotions; it has been contended that social emotions differ from other emotions as they require the representation of others' mental states (Burnett, Bird, Moll, Frith, & Blakemore, 2008) and often involve some understanding of social conventions. Researchers have thus indicated that deficits in mentalising may relate to difficulties in identifying social emotions, also known as self-conscious emotions (Heerey, Keltner, & Capps, 2003).

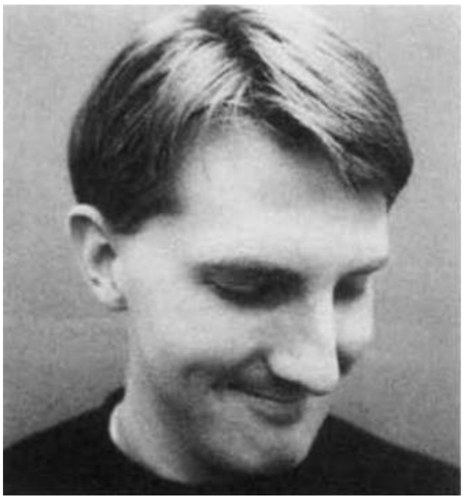

Figure 1.6: Display of embarrassment adapted from Keltner and Buswell (1997).

1.3.2 Facial expression recognition

The awareness of another person's emotions typically encompasses multimodal sensory processing. Klucharev & Sams (2004) reported that feelings and emotions of others are processed through a variety of sources such as facial expressions, body gestures as well as speech prosody. Nonetheless, it must be noted that faces alone have the capacity to convey a rich source of personal information. For example, it is known that infants process facial expressions as the primary source in identifying the emotional states of others (Woodhead, Barnes, Miell, & Oates, 1995). Typically developing individuals are able to automatically attend to and perceive the intricate set of information in a face, recognise the mental states as well as the social context, which in turn aids in the interpretation and comprehension of the entire social situation. Past research has illustrated the importance of face processing abilities and its association with the identification of facial expressions and facial identities (Bruce & Young, 1986). For instance, O'Donnell and Bruce (2001) demonstrated that the eye region of the face is important when learning to recognize new faces. Many face processing and emotional recognition studies have looked at recognition of emotions from facial expressions; some research has also examined the ability to identify other mental states from the facial region.

Premack and Woodruff (1978) believed that cognitive mental states are private phenomena which have no exterior features, hence implying that interpreting mental states from one‘s facial region would be challenging. However, Baron-Cohen, Wheelwright, and Jolliffe (1997) reported that mental states are visible from the face and stated that —the ‘eyes are the windows to the soul’, implying that the eye region displays cognitive mental states previously thought to have no external attributes. Decades before they suggested that the eyes contain vital information relating to mental states, Nummenmaa (1964) developed the Language of the Face construct. He reported that simple emotions could be recognised either by the eye or mouth region whereas complex emotions (blends of simple emotions) were recognized more from the eye compared to the mouth region. As an extension to this area of research, the Reading the Mind in the Eyes-Revised test was developed which suggested that the eyes convey salient mental state information (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001). The task consisted of 36 images depicting pictures of the eyes with four possible answer choices. The investigators found that typically developing children and adults were capable of attributing mental states to the whole face as well as the eyes. Many other researchers have replicated Baron Cohen et al.‘s findings (Corden, Chilvers, & Skuse, 2008; Hernandez et al., 2009).

In contrast, a classic study by Hanawalt (1942) showed that the mouth is the most important area of information to recognise the emotion of happiness whereas the eyes are more useful in recognising the emotions of fear and surprise. Although current research (i.e., Baron-Cohen et al.) seems to suggest that the eye region is most vital in receiving and interpreting salient information from the face, there has been contradictory evidence as to which region of the face (i.e., eyes or mouth) discloses more pertinent information in regards to the identification of mental states. It is now generally accepted that facial expressions may differ from one another with regards to where relevant information is available in the facial region (Smith, Cottrell, Gosselin, & Schyns, 2005). For example, Nusseck et al. (2008) found that the mouth region was most useful in the identification of happiness and surprise while the eye region was vital for recognition of the thinking expression.

1.3.3 Limitations of prior research

An abundance of research on mental state recognition has employed the use of static stimuli even though the intricacies of facial expressions cannot be captured in fullness in these images. Klin, Jones, Schultz, Volkmar, and Cohen (2002) suggested that the use of dynamic facial stimuli as opposed to static images provides a more holistic and appropriate representation of real life day-to-day experiences. However it can be argued that dynamic stimuli are simply a combination of a series of static images, hence the increased performance when using dynamic stimuli may actually be attributed to information from the 'additional static images'. Ambadar, Schooler, and Cohn (2005) argued that this was not the case on discovering that participants were significantly better at identifying subtle facial expressions when viewing dynamic stimuli as opposed to multi-static images. This finding adds to the evidence that dynamic stimuli encapsulate certain information not available in static images.

Furthermore, Lander and Chuang (2005) demonstrated that individuals perform better in identity recognition tasks when presented with dynamic compared with static visual stimuli. It is also not surprising that findings have shown that dynamic expressions are perceived as being more intense and realistic as compared to static images of facial expressions (Weyers, Mühlberger, Hefele, & Pauli, 2006). Research in emotional recognition tasks also supports the notion that accurate identification is increased when people are presented with dynamic as opposed to static visual stimuli (Wehrle, Kaiser, Schmidt, & Scherer, 2000). This may be explained by the supplementary information which accompanies dynamic facial visual stimuli when compared with static images. For instance people have the opportunity to appreciate the onset and offset of a particular facial expression (Schmidt, Cohn, & Tian, 2003). Moreover, the onset and offset of expressions (e.g. smile) have also been associated with accurate judgments of genuine or fake smiles (Ambadar, Cohn, & Reed, 2009). In their review of the impact of dynamic aspects of facial expressions, Krumhuber, Kappas, and Manstead (2013) highlighted the importance for future research of using the dynamic properties of facial expressions and its relation to everyday social interactions; they counsel against using static and prototypical images of facial expressions. They further highlighted the imperative role of the dynamic features in the perception of facial expressions. For instance; increased coherence for subtle expressions, the benefits of temporal sequence of unfolding expressions, as well as the activation of superior temporal sulci and amygdala which are associated with the processing of social and emotional information found only when viewing dynamic as opposed to static stimuli.

In the social world, facial expressions are typically subtle, spontaneous, transient, context-specific and are often present along with other expressions, behaviours and words (Elfenbein, Marsh, & Ambady, 2002). It seems that most researchers have not taken this into account and have often portrayed emotional responses at the very apex of the specified emotion, hence displaying emotions in an exaggerated (such as the Ekman faces) and in a less naturalistic manner (e.g. large standardised images; Corden et al., 2008). Stimuli are often void of context, static and posed, which in consequence is bound to influence the interpretation of the expressions. Facial expressions are not displayed in this manner in real-life conditions; as such, ecologically valid measures reflecting facial expressions in the real world are needed. In recognition of this, Matsumoto, Olide, Schug, Willingham, and Callan (2009) investigated cross-cultural judgements of emotions in spontaneous facial expressions amongst 548 American, British, Japanese and other international students based in the United States. They captured photographic images of Olympic Judo athletes immediately at end of a match which determines gold, silver or bronze medal as well as two other points during the medal ceremonies. All images were cropped so that only head and face could be seen. Participants were told that they would be presented with images of athletes who had just completed a match for a medal and were not told anything about the outcome of the match. They judged the athletes' expressions using a fixed-choice response task with options such as happiness, sadness, contempt, anger and surprise. The outcome of the study demonstrated that participants were able to ascribe emotions (as coded and produced by the Facial Action Coding System, FACS) significantly above chance level. Furthermore, it was found that participants' judgement of emotions were also predictive of match outcomes. Though this study captured spontaneous reactions, they were nonetheless static stills. Furthermore, the task of identifying the athletes' mental states is arbitrary at best as they may be experiencing a range of mental states which cannot easily be put into words.

This chapter introduced the research area in question. The origins and development of mentalising as well prominent theories of mentalising were discussed. Facial expression-based mental state recognition was also reviewed. Finally the limitations of prior mentalising research were considered. The next chapter details a key area of interest in this thesis- mentalising and its association with autism spectrum disorder.

CHAPTER 2

Autism Spectrum Disorder

2.1 Mentalising and clinical disorders

As introduced in Chapter 1, mentalising consists of a series of processes individuals utilise in order to understand and make sense of themselves, others and the world. There is the notion that people have evolved a framework to construct mental representations of others' beliefs, desires, thoughts, emotions, intentions and goals. That said, being in tune with others' mental states has a fundamentally inherent social function. Numerous clinical disorders encompass deficits in mentalising (Brüne & Brüne-Cohrs, 2006). In this section a few of these will be discussed.

Borderline personality disorder (BPD) is marked by a pervasive pattern of difficulties in the areas of emotion regulation, impulse control, interpersonal relationships as well as self-image (Skodol et al., 2002). Suicidal behaviours and self-harm are often noted in individuals with BPD (American Psychiatric Association, 2000). Furthermore Schneider et al. (2008) reported that 69-80% of individuals with BPD exhibit recurrent suicidal behaviours. Frequently reported comorbid disorders include anxiety disorders, depression and substance abuse and dependency (American Psychiatric Association, 2000). One of the hallmarks of BPD is a tenuous ability to mentalise as evidenced in struggles in social and interpersonal relationships. Fonagy and Bateman (2007) integrated corresponding ideas from fields of developmental psychology, psychoanalysis and cognitive neuroscience to propose a multifarious association between BPD and early attachment, physical, mental or emotional trauma, environmental factors (e.g. neglect), hyperarousal and inhibition of the orbitofrontal cortex.

Past research assessing social cognition in individuals with BPD often utilised static images such as the Ekman faces (e.g. Domes et al., 2008) and while some studies have suggested that individuals with BPD have difficulties in affect recognition in complex tasks (Dyck et al., 2009) others have not (Domes et al., 2008). In fact studies have also reported that individuals with BPD score better than control participants in classic mentalising tasks such as Baron-Cohen's 'Reading the Mind in the Eyes Test' (RMET) and Happe's advanced mentalising task (Arntz, Bernstein, Oorschot, & Schobre, 2009; Fertuck et al., 2009). Nonetheless it must be noted that the above mentioned experiments were limited in that they did not reflect real-world social contexts. Preissler, Dziobek, Ritter, Heekeren, and Roepke (2010) addressed these limitations by investigating the social-cognitive abilities of individuals with BPD using a naturalistic video-based tool called the "Movie for the Assessment of Social Cognition" (MASC) as well as the RMET. Participants were required to evaluate the movie characters' emotions, thoughts and intentions (see Figure 2.1). Results revealed that participants showed no deficits in the RMET task but were significantly impaired in the MASC task compared to healthy controls, suggesting that participants with BPD exhibited difficulties in complex real-life tasks such as this which entailed the comprehension of both verbal (literal and metaphorical) and nonverbal (facial expression and body language) communications.

Figure 2.1: An example of a multiple choice question in the MASC. Sandra stated that the recipe called for 2 cups of cream. Then Michael said to Betty "I bet if it was left to you, you'd go for 5 cups of cream, right?" The four likely answers signify varying levels of mentalising: (a) excessive mentalising; (b) no mentalising; (c) accurate response; (d) inadequate mentalising.

A recent study by Franzen et al. (2011) examined the identification of emotional signals and intentions as well as the recognition of fairness from facial expressions of others in a virtual social game. Results showed that individuals with BPD displayed superior mentalising ability as they were less influenced by emotional signals and were able to objectively detect subtle social pretexts. These results point to hypermentalising; that is mentalising inaccuracies due to over-interpretive mental state reasoning or over-attribution of intentions (Frith, 2004). This is in accordance with evidence for hypermentalising in BPD linked with hypersensitivity to social and emotional stimuli, hypervigilance as well as difficulties suppressing knowledge of unrelated aversive material (Domes et al., 2008; Lynch et al., 2006). In essence, what may seem like enhanced abilities, i.e. 'hypermentalising' in individuals with emotional instability may be just as maladaptive as having deficits in mentalising (i.e. undermentalising or no mentalising).

Another clinical disorder known to have deficits in mentalising is schizophrenia. Schizophrenia is characterized by disjointed thoughts, affect, perception and behaviour (American Psychiatric Association, 2013). The symptoms of schizophrenia fall into three categories; *positive symptoms* (e.g. hallucinations, delusions), *negative symptoms* (e.g. blunted affect, social withdrawal, and *cognitive symptoms* (e.g. difficulties in working memory, executive functioning and attention; Sadock & Sadock, 2007). Studies have shown that positive symptoms respond well to medication while negative symptoms are not easily treated (American Psychiatric Association, 2013). Furthermore even if individuals with schizophrenia reach symptom remission, high relapse rates are frequent with up to 35% of individuals experiencing relapse within 2 years following the onset of the disorder (Zhang, Wang, Li, & Phillips, 1994). Frith (1992) first proposed an association between mentalising and schizophrenia, suggesting that several symptoms of schizophrenia (e.g. social withdrawal as well as delusions of reference and persecution) can be explained by deficits in mentalising.

A meta-analysis of schizophrenia studies conducted by Sprong, Schothorst, Vos, Hox, and Engeland (2007) revealed a large and statistically significant effect size showing mentalising deficiency in all symptom subgroups. Numerous other studies have reported social cognition difficulties in individuals diagnosed with schizophrenia (Addington, Penn, Woods, Addington, & Perkins, 2008; Taylor, MacDonald, & Cognitive Neuroscience Treatment Research to Improve Cognition in Schizophrenia, 2012). Previous research has shown that individuals with schizophrenia have impairments in emotion recognition (Kohler et al., 2008; Linden et al., 2010; Tseng et al., 2013). Furthermore, it has been suggested that these deficits in emotion identification may play a part in their difficulties in interpersonal and social functioning (Pan, Chen, Chen, & Liu, 2009). Interestingly, Harrington, Langdon, Siegert, and McClure (2005) explained some of the positive symptoms such as paranoid delusions as types of hypermentalising, that is, a tendency to over-attribute mental states and intentions or to ascribe intentions when in fact there are none. On the other hand, negative symptoms have been interpreted as a form of impaired mentalising, (Tordjman, 2008). Considering the paradox of findings, Langdon, Coltheart, Ward, and Catts (2001) put forward that hypermentalising is a result of the incapacity to take appropriate perspectives; hence the deficits in typical mentalising give rise to the development of their own paranoid doubts onto people around them.

A number of other disorders have been linked with mentalising impairments, including major depression (Fischer-Kern et al., 2013); bipolar disorder (Montag et al., 2010); Huntington's disease (Brüne, Blank, Witthaus, & Saft, 2011), Parkinson's disease (Bodden, Dodel, & Kalbe, 2010) and multiple sclerosis (Pöttgen, Dziobek, Reh, Heesen, & Gold, 2013). However, one of the most prominent disorders often associated with mentalising deficiencies is Autism Spectrum Disorder (ASD), which will be the focus of the following sections.

2.2 Background of autism spectrum disorder

2.2.1 Historical accounts

ASD was first identified and characterised by two different clinicians at around the same time period, describing the condition at a behavioural level. In 1943, Leo Kanner studied 11 children whom he described as having the following shared features: difficulties in social interactions, extreme autistic aloneness, excellent rote memory, difficulty adapting to changes in routine, hypersensitivity to certain stimuli such as sound, echolalia, feeding difficulties, limited range of spontaneous activity, poor eye contact, and repetitive behaviours. Kanner categorised this set of symptoms as 'infantile autism'. However it was not Kanner who first coined this term; about 20 years prior to Kanner's description, psychiatrist Eugen Bleuler used the word 'autistic' to define the self-absorbed characteristics of patients with schizophrenia. It was derived from the Greek word 'autos' which means *self*.

Below is the original excerpt about Donald T (the first of Kanner's 11 child participants) illustrating some of the observed traits of ASD:

"Eating," the report said, "has always been a problem with him. He has never shown a normal appetite.

At the age of 1 year "he could hum and sing many tunes accurately." Before he was 2 years old, he had "an unusual memory for faces and names, knew the names of a great number of houses" in his home town. He quickly learned the whole alphabet "backward as well as forward" and to count to 100

The parents observed that "he was learning to ask questions or to answer questions unless they pertained to rhymes or things of this nature, and often then he would ask no question except in single words."

It was observed at an early time that he got happiest when left alone, almost never cried to go with his mother, did not seem to notice his father's homecomings, and was indifferent to visiting relatives. The father made a special point of mentioning that Donald even failed to pay the slightest attention to Santa Claus in full regalia.

He seems to be self-satisfied. He has no apparent affection when petted. He does not observe the fact that anyone comes or goes, and never seems glad to see father or mother or any playmate. He seems almost to draw into his shell and live within himself.

In his second year, he "developed a mania for spinning blocks and pans and other round objects." At the same time, he had a dislike for self-propelling vehicles, such as Taylor-tots, tricycles, and swings.

There was a marked limitation of spontaneous activity. He wandered about smiling, making stereotyped movements with his fingers, crossing them about in the air. He shook his head from side, whispering or humming the same three-note tune. He spun with great pleasure anything he could seize upon to spin. He kept throwing things on the floor, seeming to delight in the sounds they made. He arranged beads, sticks, or blocks in groups of different series of colours. Whenever he finished one of these performances, he squealed and jumped up and down. Beyond this he showed no initiative, requiring constant instruction (from his mother) in any form of activity other than the limited ones in which he was absorbed.

There were also innumerable verbal rituals recurring all day long. When he desired to get down after his nap, he said, "Boo[his word for his mother], say 'Don, do you want to get down?'" His mother would comply, and Don would say: "Now say 'All right.'"

(adapted from Kanner, 1943)

Hans Asperger in 1944, while working independently of Kanner described a group of children he studied as ‘autistic psychopaths’. Interestingly, they bore a striking resemblance to Kanner’s account. The key differences in Asperger’s description was the absence of delayed echolalia, instead he portrayed the children as having the ability to speak like ‘little grown-ups’ as well as some of the children’s extraordinary abilities in areas such as mathematics and art (Asperger & Frith, 1991). Both Kanner and Asperger essentially described the same condition which manifested itself in different degrees of severity and some varying symptoms. They both asserted that ASD was inherent and pervasive. Five central attributes of ASD were put forward by Kanner and Eisenberg (1957): autistic aloneness, lack of spontaneous activity, repetitive speech and behaviours, obsessive desire for sameness, and islets of ability. Islets of ability are a unique skill set that 1 in 10 individuals with ASD have (Treffert, 2007) and are also commonly known as ‘savant’ or ‘splinter’ skills. These superior cognitive or visuomotor skills may be present despite significant delays in other areas. Perhaps the most prominent examples are exceptional abilities in art, music, calculation, and memory.

It was only in the 1960s and 70s that ASD was established as a syndrome of its own and independent of other disorders such as mental retardation and schizophrenia (Happé & Frith, 1996). A large epidemiological study conducted by Wing and Gould (1979) examined children below 15 years of age who presented with acute social interaction dysfunction, language anomalies, and repetitive and stereotyped behaviours. They introduced the notion of a 'triad of impairments' often seen in people with ASD; which refers to the social symptoms i.e. deficits in communication, socialisation and imagination.

2.2.2 *Changes in concept and definition over the years*

Many of the symptoms described are still used to this day to explain the behavioural components of ASD and play a large role in our understanding of the disorder. Though ASD was recognised as a distinct disorder in the 60s, it was only in 1980 that it was included in the Diagnostic and Statistical Manual for Mental Disorders (Third Edition) as a diagnosable disorder (American Psychiatric Association, 1980). However at this time 'infantile autism' was the only form of ASD included along with 6 key criteria. A revised version was produced as the manual underwent vast changes to include more concrete diagnostic criteria of ASD suggesting that impairments should signify abnormalities in relation to one's developmental level (American Psychiatric Association, 1987). It included the triad of impairments previously mentioned as well as features of repetitive and stereotyped behaviours. In total, sixteen criteria were proposed in this edition out of which eight must be met in order to qualify for a diagnosis of ASD. The next editions (Fourth and Fourth-Revised) of the manual once again revealed variations in diagnostic criteria. A distinct category called pervasive developmental disorders was introduced and subtypes of the disorder were established (i.e. autistic disorder, Asperger's disorder, Rett's disorder, childhood disintegrative disorder and pervasive developmental disorder not otherwise specified). As opposed to the prior edition, the manual now stated that only six of 16 symptoms need to be fulfilled in order to be diagnosed with autism. For a diagnosis of autism, two of the six symptoms must be obtained from the *qualitative impairment in social interaction* category, one from the *qualitative impairment in communication* and one from the *restricted repetitive and stereotyped patterns of behaviour* (American Psychiatric Association, 2000). For a diagnosis of Asperger disorder, at least two of the social interaction criteria and one criterion from the repetitive and restricted behaviours domain must be met, with no delays in language development as well as average or above average intellectual functioning (with the latter two points being the key differentiating criteria between autism and Asperger's). The remaining two criteria to be met are that delays and abnormal functioning should be apparent prior to three years of age; and the symptoms are not better accounted for by Rett's disorder or childhood disintegrative disorder.

The latest Diagnostic and Statistical Manual for Mental Disorders (Fifth Edition) was released in 2013. Many changes have occurred once again in the domain of ASD in view of increasing diagnostic reliability and sensitivity. This new model does away with the subtypes of autism (i.e. Asperger's disorder and pervasive developmental disorder not otherwise specified) to form a more universal diagnosis with just one diagnosis of 'autism spectrum disorder' (American Psychiatric Association, 2013). The rationale for change to a single umbrella disorder is that though evidence shows that clinicians are able to reliably differentiate between ASD and typically developing children, much less reliability has been found in distinguishing between autistic disorder, Asperger's disorder and pervasive developmental disorder not otherwise specified. Furthermore differences of the three conditions have been lacking consistency and have been linked to level of language ability, intelligence, and severity as opposed to distinct symptomatology specific to each condition. Studies also indicate that the clinical presentation of high-functioning autism and Asperger's disorder is fundamentally comparable (Ozonoff, South, & Miller, 2000).

The symptom domains now have two main areas as opposed to three; the first being, *persistent deficits in social communication and social interaction* (in which all three of the criteria must be met: deficits in social-emotional reciprocity, nonverbal communicative behaviours, and developing and maintaining relationships). The second symptom domain is *restricted, repetitive patterns of behaviours* in which two of four criteria must be met (stereotyped and repetitive speech, excessive adherence to routines, highly restricted and fixated interests, and hyper/hypo reactivity to sensory stimuli). The DSM-5 criteria also cover a larger age range. Furthermore, symptom severity ratings and specifiers such as intellectual disability can be defined for a clearer picture of the presentation of disorder. Hence, people with an ASD diagnosis would be described in terms of severity of social-communication signs and severity of restricted or repetitive behaviours or interests. Many have criticised the merging of the subtypes of autism into one diagnostic category; however, the latest findings have shown that DSM-5 criteria successfully identified 91% of individuals who have previously established DSM-IV pervasive developmental disorder diagnoses (Huerta, Bishop, Duncan, Hus, & Lord, 2012) suggesting that those with past diagnoses would still retain their diagnosis of ASD under the new DSM-5 criteria.

2.2.3 Autism spectrum disorder explained

ASD refers to a complex and pervasive neurodevelopmental syndrome with core deficits in the areas of reciprocal social interaction and communication, and restricted and repetitive patterns of behaviour, interests and activities (American Psychiatric Association, 2013). The reason why ASD is recognised as a spectrum disorder is because the manifestation of the disorder can range from severe, low functioning to able, high-functioning. The prevalence of the disorder is estimated to be more than 1 in 100 in the United Kingdom, that is approximately 700000 individuals (National Autistic Society, 2013). In the United States of America, the Center for Disease Control and Prevention (CDC; 2012) estimated a prevalence of 1 in 88. A review of ASD prevalence rates in six Asian countries (China, Japan, Israel, Indonesia, Iran and Taiwan) between 1980-2008 revealed an average of 14.8 per 10000 people (Sun & Allison, 2010). Matson and Kozlowski (2011) put forward that the increasing prevalence of ASD around the globe can be attributed to factors such as heightened awareness of the condition, expanded diagnostic criteria, earlier age of diagnosis as well as the understanding that ASD is a lifelong condition.

ASD typically emerges in children by 3 years of age, though developmental delays (e.g. speech and language) and other indicators may seem apparent at an earlier age. For instance poor eye contact and joint attention, not responding when name is called, poor imitation and pretend play abilities, as well as difficulties in language and nonverbal communication (Johnson & Myers, 2007). However some children on the spectrum appear to develop typically and then go through a sudden regression and stop using previously learned language, play or social skills (Stefanatos, 2008).

Individuals with ASD share a continuum of clinical features. One of the most striking and core difficulties is in the area of social communication and social interaction. They often have trouble in social-emotional reciprocity, for instance having unusual social initiations and imitation; poor understanding of the pragmatic use of language, difficulty initiating conversation, while in other cases conversations may be very one-sided (American Psychiatric Association, 2013). Research has also shown that individuals with ASD often show reduced sharing of interests and emotions (American Psychiatric Association, 2013). People with ASD also have deficits in nonverbal communicative behaviours relevant for successful social interaction. Some examples include poor eye contact and understanding of gestures and body postures as well as inappropriate use of affect expression (may be limited or inflated). Furthermore, they face many challenges in developing and maintaining meaningful relationships as they may have difficulties in making friends, properly adapting to social contexts, and often show a general lack of interest in others.

The impairments described above contribute to the notion that there may be mentalising difficulties within this population. It seems reasonable to suggest that the combination of these complexities results in difficulties in attributing mental states to others as well as interpreting social behaviours and situations. In addition, people with ASD also have a range of non-social clinical symptoms ranging from *stereotyped or repetitive speech, motor* *movements or use of objects* (e.g. idiosyncratic speech, mannerisms such as flicking or rocking); *extreme adherence to routine and ritualised patterns* (e.g. insistence on travelling the same route); *restricted, fixated interests* (e.g. preoccupations with maps or timetables); and *under or over reactivity to sensory input in the environment* (e.g. high tolerance for pain, licking or sniffing of objects). In order to qualify for a diagnosis according to the DSM-5, individuals should meet a number of the symptoms mentioned above. In addition, the symptoms should be present in early childhood and together result in impairments in daily functioning (American Psychiatric Association, 2013).

Though it has been over 60 years from the time ASD was first described, the causes of this disorder are yet to be known though research suggests a multitude of factors. A great deal of evidence supports a genetic basis (e.g. mutations, deletions) for the development of the disorder (Muhle, Trentacoste, & Rapin, 2004). In addition to studies which have started to reveal specific biomarkers for autism, a number of behavioural genetics studies, looking at familial risk indicate a definite genetic basis to the condition. Among families who already have a child with ASD, there is a 2% to 8% likelihood that another sibling will also have the condition (Ozonoff et al., 2011). A large number of individuals diagnosed with ASD also often have Fragile X syndrome, tuberous sclerosis and other related genetic and chromosomal conditions (Sadock & Sadock, 2007), although there is debate whether individuals with a genetic disorder of known etiology should be given a diagnosis of ASD if they meet DSM criteria.

Although genetic factors have proven to play a large role in this disorder, studies suggest that the manifestation of the genetic predisposition may be influenced by various environmental factors; for example the exposure to teratogens such as thalidomide in early pregnancy (Landrigan, 2010). Other risk factors include increased maternal and paternal age

(Grether, Anderson, Croen, Smith, & Windham, 2009) as well being born extremely preterm (Johnson et al., 2010).

Certain neuroanatomical differences have also been reported in the ASD population. Pickett and London's (2005) review reported atypical growth of the forebrain limbic system and reduced number of Purkinje cells in the cerebellum. The following three brain structures have been implicated in playing key roles in social cognition deficits in ASD; amygdala, the superior temporal sulcus region and the fusiform gyrus (Pelphrey, Adolphs, & Morris, 2004). Wang, Dapretto, Hariri, Sigman, and Bookheimer (2004) reported that children with ASD showed significantly less activity compared to healthy controls in the fusiform gyrus in an emotion matching task and that amygdala activity was not moderated by task demands. Reduced activity in the left and right superior temporal sulci and gyri have also been reported (Gervais et al., 2004). Furthermore, in Critchley et al.'s (2000) study with implicit and explicit emotion processing tasks, it was revealed that adults with ASD failed to activate the amygdala in the implicit (unconscious) task while they failed to activate the fusiform gyrus in the explicit (conscious) task. On the whole, studies have suggested that people with ASD may utilise different neural networks in processing everyday tasks and information.

In addition, studies have demonstrated that certain subgroups are at higher risk for developing ASD than others. Data has revealed that boys are five times more likely to have ASD compared to girls (Center for Disease Control and Prevention (CDC), 2012). Volkmar, Cook, Pomeroy, Realmuto, & Tanguay (1999) reported that about 70%-75% of individuals with ASD function in the borderline to mentally disabled range of intellectual functioning while about 30% are in the average range (Sadock & Sadock, 2007).

While ASD is a pervasive condition, various methods of intervention have been developed over the years to improve the overall quality of life as well as to promote integration into the community. Examples of intervention models often utilised within the ASD population are behaviour management, early intervention, educational and school based therapy, occupational therapy, social skills training and speech therapy (Volkmar et al., 1999). Many of the intervention models are targeted at children with ASD as research has shown that early intervention greatly improves therapeutic outcomes (Volkmar et al., 1999).

2.2.4 How is autism spectrum disorder diagnosed?

As many characteristic behaviours of ASD are apparent in the early years, children are often diagnosed with ASD at around 3 years of age. At the initial stage, clinicians frequently rely on behavioural traits to evaluate the presence of the condition. Multiple ASD screening tools have been developed to briefly assess children's social and communication developmental levels. These tools are commonly used in paediatric and sometimes even educational settings, such as the Modified Checklist for Autism in Toddlers (M-CHAT; Robins, Fein, Barton, & Green, 2001); while the Autism Spectrum Screening Questionnaire is used for older children (ASSQ; Ehlers, Gillberg, & Wing, 1999). These screeners are designed to signal any possible indicators of an ASD and to warrant a comprehensive evaluation should it be necessary. The following step involves a wide-ranging assessment in order to accurately ascertain the presence or absence of ASD or any other developmental condition. A thorough evaluation is often conducted by a multidisciplinary team of professionals some of whom may be psychologists, developmental paediatricians, neurologists, speech therapists, psychiatrists and other relevant professionals involved in the diagnoses of people with ASD. Complete case histories are evaluated in order to get a clear understanding of the individual's developmental, medical and family background. Tests of intellectual functioning are often conducted to determine current level of cognitive reasoning ability, to understand preferred learning styles and to guide intervention initiatives. Other areas of psychological evaluation are day-to-day adaptive functioning, play skills, motor and visuomotor skills as well as social cognition (Klin, Saulnier, Tsatsanis, & Volkmar, 2005). Another crucial aspect in the diagnosis of ASD is the assessment of speech, language and communication ability. The assessment is not only limited to the technical components of speech and language development such as phonology, syntax and vocabulary; as socially relevant communicative areas such as prosody, metalinguistics, pragmatics, and social reciprocity are also examined.

In addition to the various evaluations noted above, there are two instruments which have been designed for use as ASD diagnostic tools and are now considered the 'gold standard' of ASD diagnostic procedure (Falkmer, Anderson, Falkmer, & Horlin, 2013)- the Autism Diagnostic Interview-Revised (ADI-R; Rutter, Le Couteur, & Lord, 2003) and the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000). The ADI-R is a semi-structured interview to be administered to parents or primary caregivers and can be used for diagnostic purposes for individuals with a mental age of at least 18 months. The interview consists of four core domains being early development (e.g. developmental milestones), social communication (e.g. reciprocal conversation, nonverbal communication, echolalia) social development and play skills (e.g. eye contact, pretend play, prosocial behaviours), and repetitive and restricted patterns of interests and behaviours (e.g. bizarre preoccupations, motor mannerisms ritualistic behaviour, unusual sensory interests). Information obtained from the interview about an individual's developmental history and present behaviours is then converted into a scoring algorithm which is compatible with the DSM-IV criteria for ASD (a new algorithm consistent with DSM-5 is presumably in the pipeline).

While the ADI-R looked at obtaining comprehensive information relevant to ASD from caregivers, the ADOS operates on a direct observational structure with the primary goal of assessing spontaneous communication, reciprocal social interaction, and play skills in an informal and naturalistic manner (but within a clinical context). It can be used for both children and adults and is also suitable for use with individuals who are nonverbal as well as those who have fluent speech. Typical administration of the ADOS requires approximately 30-45 minutes. There are four modules in the ADOS, with the appropriate module being selected based on the individuals' level of verbal language and chronological age. The minimum expressive language requirement for Module 1 is no speech, while the maximum being simple phrases. Module 2 requires a minimum of flexible three-word phrases up to a maximum of verbally fluent. Module 3 is typically administered to verbally fluent children or young adolescents whereas Module 4 is intended for verbally fluent adolescents and adults. The expressive communication subdomain of the Vineland Adaptive Behaviour Scale (VABS; Sparrow, Balla, & Cicchetti, 1984) is a useful guide in gauging module appropriateness. In general children who obtain an expressive language score of at least 30 months can be administered Module 2 while Module 3 and 4 are suited for individuals who are functioning verbally at least at the 48 months level.

Module 1 consists of 10 activities which can be administered flexibly with an emphasis on the use of toys and other items relevant to children below the age of three. It includes a series of fun and playful 'presses', that is, conditions created specifically to scrutinise spontaneous behaviours in the respective conditions. Some of the activities in Module 1 are *free play* (e.g. to observe independent use of toys, and presence of repetitive behaviours); *bubble play* (e.g. to elicit eye contact and verbalisation) and *birthday party* (e.g. to see the child's capacity to engage in functional and symbolic play). Module 2 contains 14 activities again with an emphasis on the playful use of toys, aimed at children who have phrase speech. Examples of Module 2 activities include *conversation* (e.g. to examine the child's capacity to have a simple verbal reciprocal exchange); *snack* (e.g. to observe the child's ability to make requests) and *demonstration task* (e.g. to view the child's proficiency in relating a common sequence of actions through gestures). The activities in Module 3 and 4 on the other hand focus on social, communicative and language behaviours. Module 3 includes activities such as *emotions* (e.g. to probe the individual's description, understanding and instance of experiencing at least two emotions) and *social difficulties and annoyance* (e.g. to examine the individual's awareness of social difficulties and sense of responsibility for their own actions). Examples of activities in Module 4 are *friends and marriage* (e.g. to acquire the individual's explanation of personal friendship experiences and to ascertain the individual's understanding of the concept of friendship, steady couple relationships and starting a family) and *plans and hopes* (e.g. to probe the individual's ambitions and aspirations).

The observations are then coded in accordance with meticulous criteria whilst taking into account vital diagnostic components such as facial expressions, social reciprocity, prosody, gestures, idiosyncratic use of language as well as imagination and creativity (Klin et al., 2005). All ADOS modules have Communication, Reciprocal Social Interaction, Imagination/Creativity and Stereotyped Behaviours and Restricted Interests subscales. However, only the Communication and Reciprocal Social Interaction scores contribute to the overall diagnostic scores; with the autism cut-off being 10 and the autism spectrum cut-off being 7. Similar to the ADI-R, the diagnostic algorithm of the ADOS is compatible with DSM-IV. The ADI-R and ADOS are frequently used together by clinicians in the diagnostic process in order to gain pertinent information from these complementary sources. In 2012, the ADOS-2 was released with an additional Toddler module enabling the assessment of children as young as 12 months old.

2.3 Autism spectrum disorder and the theory of mentalising

Mentalising was discussed in detail in Chapter 1; in this section mentalising is considered in relation to ASD. This theory fundamentally states that individuals with ASD fail to "impute mental states to themselves and others" (Premack & Woodruff, 1978, p. 515). Similarly, Baron-Cohen, Leslie, & Frith (1985) stated that individuals with ASD have difficulties in understanding the minds of others i.e. mentalising. The problems people with

ASD have in comprehending the mental states of others could explain some of the symptoms characteristic of the disorder. If there is no understanding that different minds have varying mental states and that people act upon them accordingly, it would prove to be extremely arduous to apprehend and anticipate the behaviour of others, resulting in problems with meaningful social relationships and interactions. Difficulties in social communication can also be related to deficits in mentalising as the understanding of social reciprocity and body language (among others) is vital in successful communication. The mentalising theory of autism however does not extend to explain other ASD symptoms i.e. restricted and repetitive patterns of behaviour as well as savant skills (Rajendran & Mitchell, 2007). Impairments in executive functioning have been proposed to account for the non-social features of ASD such as repetitive and restricted behaviours as well as insistence on sameness. Executive functioning refers to a set of higher-order control processes often utilized in complex or novel situations. These include set-shifting, the use of working memory, observing and planning behaviours, and inhibiting automatic responses (Happé, 1999). On the other hand, savant skills in ASD may be explained by the cognitive model of weak central coherence. Frith (2003) described central coherence as a form of information processing aimed at drawing together material to create a 'cohesive' model which enables the selecting of only relevant information and disregarding the rest. While typically developing people are able to do this, individuals with ASD may have a 'weak' central coherence, hence perceiving information disjointedly without bearing in mind context and the meaning of the information at hand. Thus it is clear that none of the three cognitive accounts (i.e. mentalising, executive function, weak central coherence) adequately explain all facets of ASD individually. As ASD is a multifarious condition with some individuals displaying certain aspects and others not, Baron-Cohen and Swettenham (1997) proposed that the cognitive accounts should be ascribed independently.

A great deal of research has examined people’s ability to mentalise using a variety of false belief tasks (e.g. Max-chocolate and crayon-candy tasks as detailed in Chapter 1). Baron-Cohen, Leslie, and Frith (1985) first investigated mentalising abilities of children with ASD with the seminal Sally-Anne task. In the task, the children are told a story of a character called Sally who places a marble in a basket, then leaves the room. Then another character called Anne moves the marble from the basket to a box, resulting in Sally’s false belief about the location of the marble when she returns to the room looking for the marble. Children are then asked where Sally thinks the marble is located or to guess where Sally will first look for the marble (i.e. belief question) (see Figure 2.2). Children were also asked two control questions in order to establish that they understand where the marble was originally placed (i.e. memory question) and understand where the marble’s current location is (i.e. reality question). Essentially, this is the same problem devised by Wimmer and Perner in the 'Max' task - however, the story is adapted a little to further simplify the narrative for children with ASD. In order to pass this task, children must comprehend that Sally has a false belief and select the basket as the location where she will look, although in reality the children themselves should be aware that the marble is now placed in the box. The findings revealed that although the mental age of the children with ASD was higher than the comparison children with Down Syndrome and healthy controls, and certainly higher than the age of four years (at which typically developing children tend to succeed at this task) about 80% of children with ASD failed to predict accurately where Sally would look for the marble while the majority of children in comparison groups were able to. As children with Down's Syndrome could appreciate the protagonist's false belief, the findings have been interpreted as suggesting that children with ASD have a specific deficit in comprehending the mental states of others.

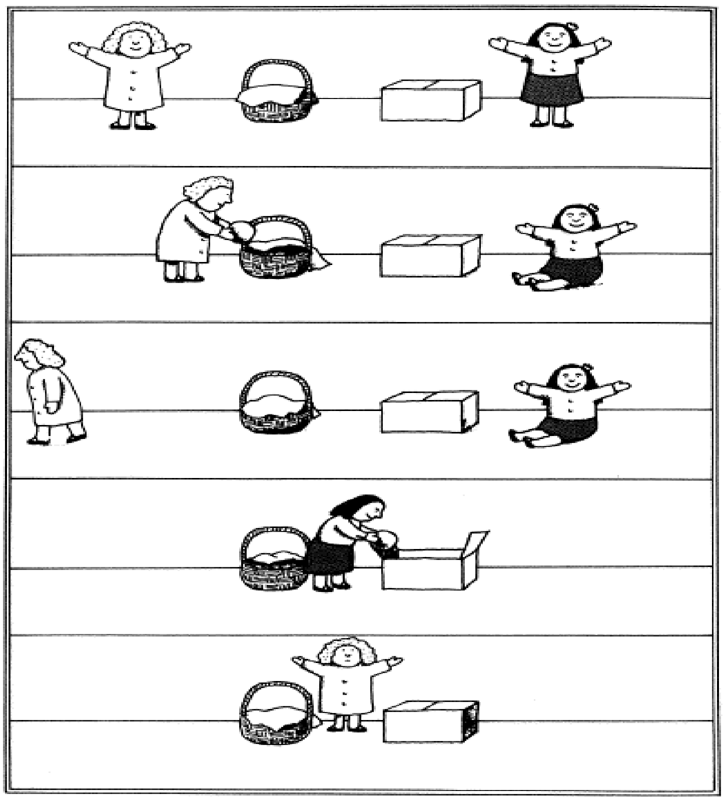

Figure 2.2: The Sally-Anne task (adapted from Frith, 2003).

Perner, Frith, Leslie, and Leekam (1989) investigated false belief attribution using the deceptive box paradigm (i.e. unexpected contents task as described in Chapter 1). They found that almost 85% of the children with ASD aged between 3 to 13 years of age showed difficulties recognising false beliefs by predicting that another child would state that a pencil was inside the container; conversely the comparison participants successfully acknowledged another child's false belief by predicting that he/she would think that container had sweets inside (see Figure 2.3).

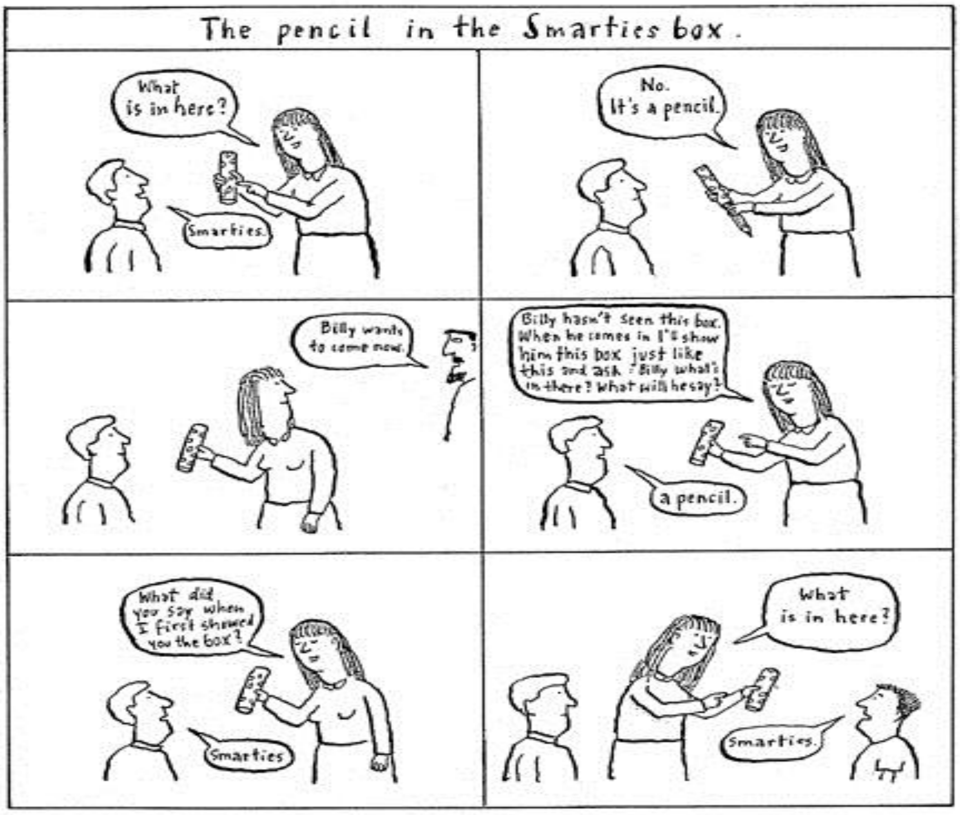

Figure 2.3: An illustration of the Smarties Task (adapted from Happe & Frith, 1999).

Though the above-mentioned studies provide convincing evidence that children with ASD have difficulty understanding false beliefs, it must be noted that a minority of the group with ASD in fact passed the false belief tasks, which led some critics to suggest that if there is a deficit in mentalising in ASD, this may not be universal. To combat this criticism, Baron-Cohen (1989) then put forward the notion of mentalising impairments in individuals with ASD as a delay rather than a deficit. In other words, he suggested that some individuals with ASD may acquire the ability to mentalise, but that this acquisition would occur at a later age than for individuals of typical development or those with other types of developmental disorders. However a range of subsequent studies examining false belief understanding in children, adolescents and adults with ASD revealed that individuals with high-functioning ASD i.e. those with average or above average intelligence were able to pass first-order (i.e. acknowledge another person's false belief with regards to real events) as well as second order false belief tasks (i.e. 'he thinks she thinks', to assign false belief to one person based on the thoughts of another person; Bowler, 1992; Dahlgren & Trillingsgaard, 1996; Tager-Flusberg & Sullivan, 1994). Nevertheless proponents of the mentalising deficit account of ASD have argued that even passing more complex false belief tasks should not be taken as a valid indication of having proficient mentalising abilities as it has been shown that these tasks have a ceiling rate which parallels a mental age range of between 4 to 8 years (Perner & Wimmer, 1985; Tager-Flusberg & Sullivan, 1994; Wellman, Cross, & Watson, 2001).

Consistent with this analysis, Happé (1995) demonstrated a strong correlation between false belief task performance, IQ and verbal language ability; children with ASD with a verbal mental age of 12 years and above were able to pass first-order false belief tasks. The age at which children with ASD almost always pass these first-order tasks signifies a vast delay as compared to neurotypical children who successfully accomplish this task at about the age of four (Wellman et al., 2001). In light of the association between verbal language ability and performance on false belief tasks, it is within reason that people with ASD who have strong verbal ability or are high functioning may perform at ceiling level in given first-order and second-order false belief tasks. Essentially, it has been suggested these individuals may be able to develop strategies which they can use to reason through the tasks and respond with the correct answer, albeit perhaps through a different process than that routinely used by typically developing individuals. Frith, Happé, and Siddons (1994) proposed that individuals with ASD are perhaps passing these tasks by 'hacking' out solutions. Though 'hacking' is not clearly outlined, they appear to suggest that people with ASD solve first and second-order false belief tasks through rule-based learning in what they may comprehend as logical problem solving. Hence it is conceivable that people with ASD have universal difficulties in mentalising even though standard simplistic false belief tasks are not sensitive enough to uncover these difficulties within the subgroup of high functioning, verbally able individuals with ASD.

2.3.1 Advanced tests of mentalising

Numerous 'advanced' mentalising tasks were then developed in order to address the shortcomings of the previous tasks with the aim of creating more sensitive measures for examining mental state attribution in the ASD population. It is notable that these generally do not involve false belief attribution and in fact they differ widely in terms of their nature. One of the foremost advanced tasks of mentalising to be developed was the Strange Stories task (Happé, 1994). The task comprised 24 short stories or vignettes about simple everyday situations in which people say things which are not meant to be taken literally. The participants are required to read the story and then answer questions about why protagonists in the stories said what they did. The naturalistic quality of this task was expected to prove to be challenging for people with ASD as it required understanding of the relevant social contexts presented in the stories. The results of the study showed that the participants with ASD were worse compared to neurotypical and mentally disabled controls at offering mental state descriptions of the characters in the stories that were appropriate for the given social context. It was also demonstrated that individuals with ASD who passed first and second-order belief tasks nevertheless provided inaccurate mental state explanations for some of the stories as compared to healthy controls who made no such errors. This therefore appears to provide some support for the notion that individuals who pass second-order false belief tasks might still have residual impairment in mentalising. Other studies utilising the Strange Stories task have replicated these findings that children, adolescents and adults with high functioning ASD and Asperger syndrome perform less well compared to neurotypical individuals (Jolliffe & Baron-Cohen, 1999; Kaland et al., 2005).

Another widely used advanced test of mentalising is the 'Reading the Mind in the Eyes ' test which involves attributing mental states to the eye region of the face (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997; Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001). The task, which is also described in Chapter 1, consisted of presenting a series of static pictures depicting simple and complex mental states from the eye region of the face. Participants selected which of four words they thought best portrayed what the person in the photograph was feeling or thinking (see Figure 2.4). The emphasis on the eye region was established as a prior study (Baron-Cohen, Wheelwright, Jolliffe, & Therese, 1997) demonstrated that although people with ASD were able to identify what they described as basic mental states or 'emotions' (e.g. sad, happy), they were impaired at identifying something they described as 'complex mental states' (e.g. shy, guilt) when only the eyes were exhibited. The findings in the 2001 study revealed that individuals with ASD performed poorly at identifying mental states when presented pictures of the eyes as compared to controls. Again, these findings have been interpreted as suggesting that while high functioning individuals with ASD may be able to pass false belief tests, they still have impairments imputing mental states which can be made apparent if a task of sufficient difficulty is devised.

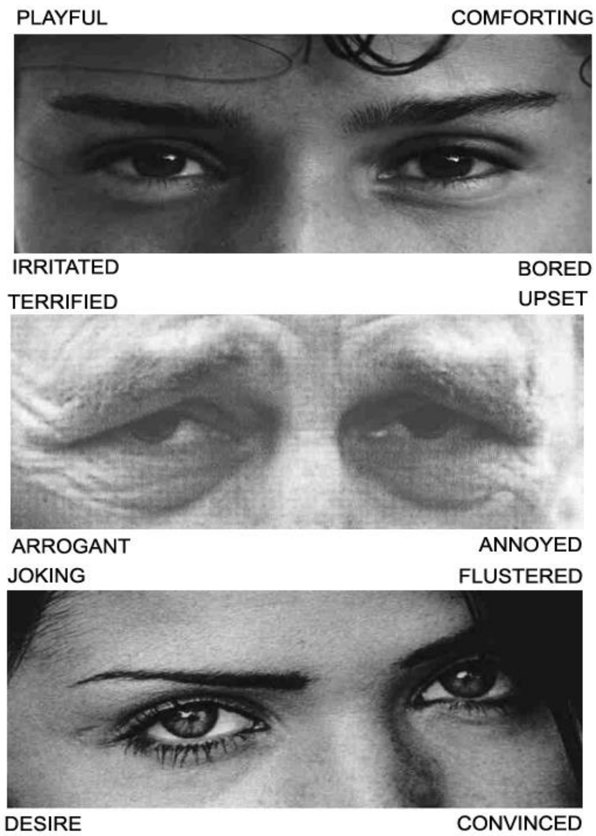

Figure 2.4: A sample of the 'Reading the Mind in the Eyes' test (adapted from Baron-Cohen et al., 2001). The answers are (from top down); playful, upset and desire.

Part of the appeal of Baron-Cohen's et al.'s (2001) findings was that they seem to accord well with anecdotal reports that individuals with ASD tend to have unusual eye contact, and in particular to avoid eye contact. Indeed, one of the indicators taken into account in the ADOS is having abnormal eye contact behaviour. If people with ASD do not like to look at the eye region of the face, and if this same region has crucial information for identifying others' mental states, then this could explain how some of the social difficulties in ASD come about. Following Baron-Cohen's study, there has been an increasing number of studies investigating face perception in individuals with ASD, including studies involving eye tracking techniques which aim to identify how individuals with ASD attend to social stimuli, and in particular the eyes.

2.3.2 Mentalising and the eye region

Hernandez et al. (2009) studied the eye gaze behavior of 11 adults with ASD and 23 neurotypical individuals in a face processing task involving neutral faces (with direct or averted gaze), faces portraying an emotion (i.e. happy or sad) and a range of computer-generated faces. A total of 50 static images of models depicting neutral, happy and sad expressions along with the computer-generated images were presented to participants for 4 seconds each. They reported that although individuals with ASD spent more time looking at the eye region compared to the other areas of interest i.e. mouth and nose, they spent less time looking at the eye region as compared to the neurotypical participants.

Instead of using static images, Klin, Jones, Schultz, Volkmar, and Cohen (2002) created an elegant experiment using intense emotional excerpts from the classic 1966 film entitled 'Who's Afraid of Virginia Woolf?'. Fifteen participants with ASD and 15 healthy controls viewed 5 digitized videoclips of social scenes (ranging between 30-60 seconds each) from the movie while being eye-tracked (see Figure 2.5). Consistent with Hernandez et al. (2009), they found participants with ASD visually fixated less on the eye region of the face as compared to healthy controls. They also demonstrated that individuals with ASD spent more time fixating on the mouth region and that was linked with improved social adaptation and a lesser degree of social impairment related to ASD. In contrast, findings also revealed that individuals with ASD spent more time looking at the objects in the social scenes as compared to healthy controls and this was associated with lower social adaption and a higher degree of ASD-related social impairment.

Figure 2.5: Sample visual fixation of a person with ASD (red) and neurotypical (yellow) while watching a social scene depicting a shocked actor (adapted from Klin, Jones, Schultz, Volkmar, & Cohen, 2002a).

Rutherford and Towns (2008) investigated the looking patterns of 22 people with (*n=11)* and without (*n=11)* ASD in an emotion recognition task, using images sourced from Baron Cohen et al. (1997). Participants were shown 20 images of a female face portraying various simple emotions (e.g. happy, angry, surprise) and complex emotions (e.g. scheming, flirting, arrogant). Participants were presented with the images twice through (totalling 40 trials) followed by 2 emotion words, with only one emotion word being the correct response (see Figure 2.6 and 2.7 for a sample of participants' eye gaze path). They reported that both ASD and neurotypical participants looked significantly longer at the eye region as compared to the mouth. Nonetheless participants with ASD were found to look less at the eyes compared to neurotypicals paricularly when viewing complex emotions.

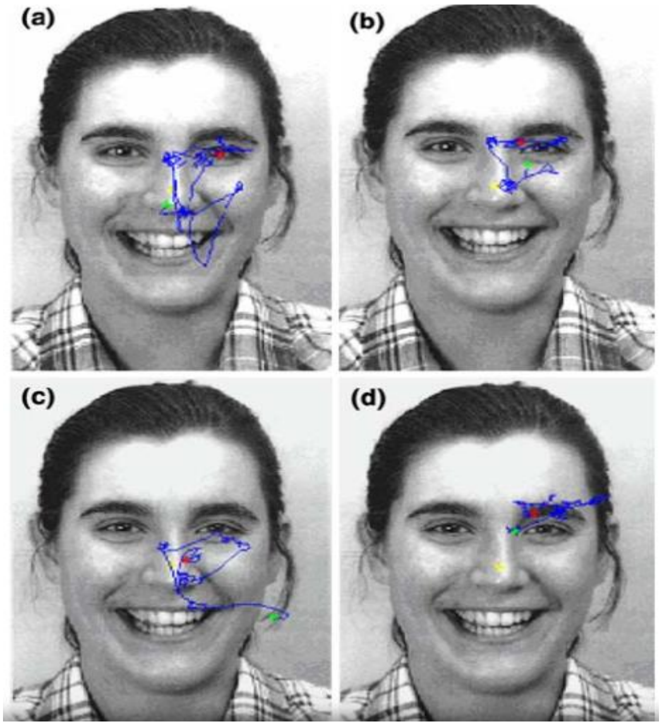

Figure 2.6: Visual gaze patterns for 'happy' facial expression of 4 neurotypical participants (adapted from Rutherford & Towns, 2008).

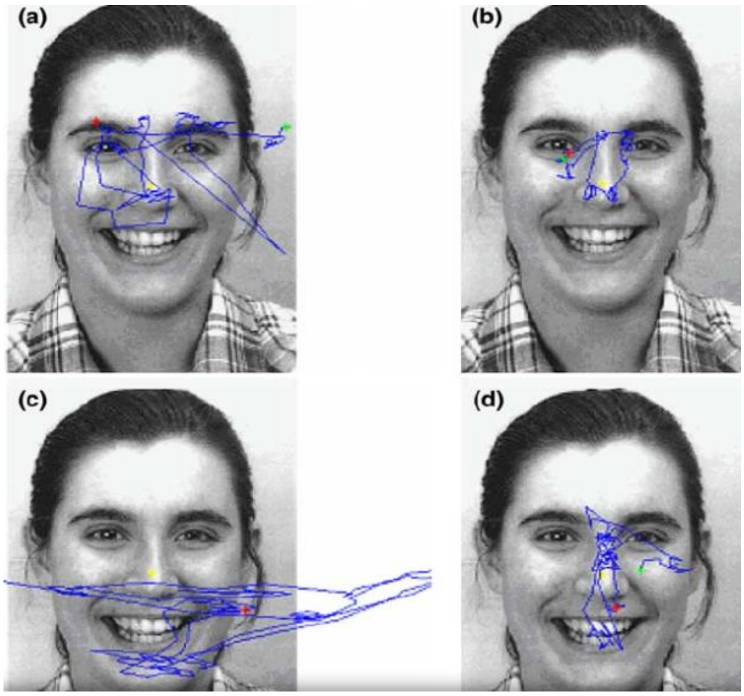

Figure 2.7: Visual gaze patterns for 'happy' facial expression of 4 participants with ASD (adapted from Rutherford & Towns, 2008).

To further investigate how people with ASD process information from the eye region of the face, Freeth, Chapman, Ropar, and Mitchell (2010) investigated the eye gaze behaviours of 24 individuals with high-functioning ASD and 24 matched healthy controls. Individuals were presented with complex photo images containing one person either looking directly at the camera or looking at an object within the scene (see Figure 2.8). All images depicted daily and familiar settings such as an office or living room. Individuals were presented with 8 different images, in four of which the person in the photo had straight gaze while the remaining four showed the person looking towards an object. Freeth et al (2010) conducted two experiments wherein images were displayed for 5 seconds in Experiment 1, while they were displayed for 2 seconds in Experiment 2. The findings revealed that both ASD and neurotypical participants spent a considerable amount of time fixating on the face of the person in the images, specifically the upper part of the face containing the eyes. They also found that typically developing participants were quicker to fixate on the face as opposed to individuals with ASD, who were faster to fixate on objects in the image. In addition, results showed that individuals with ASD responded to eye gaze signals as did neurotypical individuals by looking at the object when the person in the photo was gazing towards it. However, they did not concentrate as much on the object looked at by the person in the image as the neurotypical individuals did.

Figure 2.8: An example of an image showing the person gazing towards an object (adapted from Freeth et al. 2010).

Nonetheless, findings that individuals with ASD demonstrate reduced fixation to the eye region has been inconsistently found in subsequent studies. A recent study showed that individuals with and without ASD spent longer time looking at the eye region as compared to the mouth region of the face in both basic and complex emotion recognition tasks although the accuracy rates of individuals with ASD in the emotion recognition task were poorer than healthy controls (Sawyer, Williamson, & Young, 2012). This suggests that the traditional view of mental state recognition impairment and its link to eye gaze aversion may not sufficiently explain these difficulties.

In contrast to previous findings, Song, Kawabe, Hakoda, and Du (2012) demonstrated evidence of the ability of children with ASD to interpret information from the eye region. Using the 'Bubbles' method, 15 children with high-functioning ASD and 18 typically developing children were asked to judge identity and emotions based on images of facial features. It was reported that similar to the typically developing controls, children with ASD inferred information from the eyes for both the identity and emotion judgement tasks. Additionally, they performed as well as their counterparts in both tasks, contesting the premise that people with ASD cannot pay attention to the eye region or obtain pertinent information from the eyes of others. In addition, Corden, Chilvers, & Skuse (2008) contributed to the range of studies which have illustrated the challenge of reliably establishing a relationship between mentalising performance and eye gaze behaviour in an experimental task. In their study, 42 participants (21 with ASD and 21 healthy controls) completed the Ekman-Friesen test of facial affect recognition in which they were presented with 60 emotionally expressive face images in two phases. The first being the 'free-viewing' phase with no experimental task and the second phase called for a judgement of the emotion being expressed in the images. The images were shown in randomised order in the first phase of the eye-tracking experiment while it was shown in the standardised order in the second phase. The findings of this study revealed that the difficulty individuals with ASD have in fixating in the eye region was only reflected in their impairment in identifying the expression of fear in faces and not the recognition of the other presented facial expressions.

While the studies reviewed above had an emphasis on eye region and mentalising ability, the following section discusses mentalising ability and studies related to face processing in general. Literature on mental state recognition via face processing studies involving individuals with ASD has been variable. While some studies have reported that individuals with ASD have no difficulties in affect recognition tasks (e.g. Adolphs, Sears, & Piven, 2001; Rutherford & Towns, 2008) others have demonstrated that they have deficits in identifying certain mental states such as disgust, surprise and anger (Law Smith, Montagne, Perrett, Gill, & Gallagher, 2010) as well as fear (Corden et al., 2008). Studies of children with ASD revealed that they had deficits in detecting anger and needed more time compared to typically developing children to accurately detect other mental states (Bal et al., 2010). Similarly, Rump, Giovannelli, Minshew, and Strauss (2009) demonstrated that the children with ASD in their study were impaired in identifying negative emotions particularly anger and fear. They also reported that while emotion recognition performance increased with age in the typically developing group, the performance of individuals with ASD was relatively comparable in all age groups. The paradoxical findings may be related to the strength at which these mental states are displayed, as people with ASD show difficulties in identifying mental states shown at lower intensity (Law Smith et al., 2010). The need for higher intensity facial expressions for correct emotion identification (Wallace et al., 2011) can be related to daily social interactions as most facial expressions are understated which could offer an explanation for the difficulties people with ASD have in day-to-day interactions. Furthermore, in real-life people typically display a mixture of facial expressions conceivably making this task more difficult for individuals with ASD.

If individuals with ASD have trouble recognising basic emotions, how would they fare in the identification of social emotions (as described in

Chapter 1)? As social emotions require the understanding of social rules and the representation of another person's mind, mentalising tasks using social emotions should reveal deficits within the population with ASD. Golan, Baron-Cohen, and Golan's (2008) study found that children performed worse in the identification of complex social emotions in the 'Reading the Mind in Films' task. On the whole, the literature suggests that although individuals with ASD may be able to recognise basic mental states, the identification of both basic and complex mental states is more demanding particularly in real-life settings with displays of instantaneous behavioural responses.

2.3.3 Mentalising tasks using dynamic and naturalistic stimuli

Speer, Cook, McMahon, and Clark (2007) examined the eye gaze patterns of individuals with ASD while watching dynamic social scenes and static pictures from the film 'Who's Afraid of Virginia Woolf?' Participants were presented with four kinds of stimuli; social dynamic, social static, isolated dynamic and isolated static. It was found that ASD and typically developing individuals gaze patterns varied only for dynamic stimuli, but not for static stimuli. Findings also revealed that individuals with ASD differed from their neurotypical counterparts only when viewing the social dynamic stimuli, gazing less at the face and more at the body regions. The results suggest that individuals with ASD may have a tendency to show different visual gaze patterns for dynamic, realistic and socially intricate stimuli though it must be noted that the stimuli presented was adapted from a film over 40 years old with extremely intense and larger-than-life emotional expressions.

Similarly, Back, Ropar, and Mitchell (2007) further provided evidence for the difficulty people with ASD have in interpreting mental states from dynamic facial stimuli. Their study investigated the ability of people with ASD to infer mental states from static and dynamic facial stimuli. They developed a technique called 'freezing' in which either the eyes or mouth sections of the face were fixed on a static and neutral expression. Participants were then presented with a series of stimuli in different combinations of 'freezing', which enabled further examination of which parts of the face was used to infer mental states. In one experiment, they studied 18 individuals with ASD aged between 10-14 years of age and found that although individuals with ASD were able to attribute a range of mental states to static and dynamic facial expressions, they were not as successful as typically developing controls (for instance in inferring complex mental states such as worry from dynamic faces). It was also found that individuals with ASD performed better in the task when the eyes and mouth regions were not 'frozen' (i.e. conveyed information), suggesting that people with ASD do make use of information from the eye region.

Perhaps the reason why group differences are more often found using dynamic stimuli is because such tasks more closely approximate the mentalising requirements of everyday life. Various studies using stimuli that have real-life social relevance have found group differences, such as the Social Attribution Task (Klin, 2000), the Faux Pas test (Spek, Scholte, & Berckelaer-Onnes, 2009), and the Cambridge Mindreading Face-Voice Battery (Golan, Baron-Cohen, & Hill, 2006). It is worth noting that Baron Cohen et al.'s (2001) findings were not replicated in a study conducted by Roeyers, Buysse, Ponnet, and Pichal (2001) as they found that adults with ASD were not impaired in the 'Reading the Mind in the Eyes ' test. Interestingly however, these participants had difficulties in deducing emotions from videos of people in real-world social interactions. Other studies have demonstrated consistent findings whereby adults with ASD showed impairments in identifying complex mental states such as 'admiring' from social scenes in films as indexed through the 'Reading the Mind in Films' task (Golan, Baron-Cohen, Hill, & Golan, 2006). Similarly, the Awkward Moments Test (Heavey, Phillips, Baron-Cohen, & Rutter, 2000) was designed to approximate the demands of real-life mentalising in people with ASD. Participants were presented with film excerpts obtained from television advertisements and were required to answer two questions; one in regards to a character's mental state and another non-social question. The findings once again revealed that participants with ASD scored significantly worse than neurotypical controls in questions that required mentalising ability. Hence it may be that individuals with ASD have more difficulty inferring mental states from dynamic (moving) as opposed to static stimuli whereby the former consists of behavioural responses which are often fleeting and understated.

Nevertheless, it must be noted that all the mentalising tasks reviewed above depict dynamic yet 'acted' facial expressions and behavioural responses. Though more efficient than static stimuli to investigate mentalising ability, the use of 'posed' dynamic stimuli nevertheless introduces the risk of losing the true sense of real-world interaction. In addition to this, correct answers to the acted stimuli are often decided by means of consensus, which by extension suggests that the true mental state of the actor is unknown, as the actor merely followed directions and portrayed what was instructed of him or her. Perhaps the only published study that has used non-posed stimuli was conducted by Boraston et al. (2008), who investigated the ability of people with ASD to distinguish between images of people displaying either posed smiles or spontaneous genuine smiles. They found that people with ASD were impaired in determining posed vs. genuine smiles and that performance on the task correlated with social interaction competence as measured by the ADOS. While this study successfully revealed that individuals with ASD have difficulties in recognising between posed and fake smiles, their ability in distinguishing between a wider array of naturalistic situations is not yet known.

On the whole, the dynamic qualities of facial behaviour are especially imperative to face processing studies as it has been associated with increased performance in emotion identification tasks, particularly for subtle stimuli (Krumhuber, Kappas, & Manstead, 2013). To the researcher's knowledge there is no published study that has efficiently investigated mentalising abilities in individuals with ASD using the essential components mentioned above. In recognition of this, one of the primary goals of this thesis was to create a paradigm to tackle these limitations, specifically to create stimuli which are dynamic, naturalistic *and* spontaneous.

2.4 Significant components of studying difficulties in mentalising

2.4.1 Naturalistic and spontaneous mental state recognition

A review of relevant literature and the importance of utilising naturalistic, spontaneous and dynamic stimuli was deliberated in section 2.3.3. As evidenced by a dearth of studies in the area, the development of new techniques to explore people's capacity to interpret spontaneous and naturalistic stimuli is essential. Nonetheless past research has often investigated people's ability to impute mental states via direct identification of a mental state (which has its own set of limitations as previously discussed in Chapter 1); hence a better method of mental state identification is warranted.

As discussed in previous sections, although people with high-functioning ASD are able to pass standard tests of mentalising, they continue to struggle in daily social interactions. This suggests that they may have subtle difficulties which have been frequently overlooked in the past. Given these striking yet inconspicuous difficulties, a technique to examine mentalising ability within the population with ASD is necessitated, in particular using naturalistic and spontaneous stimuli (i.e. that are ecologically valid and representative of real-world situations) as well as employing a method that is objective and empirical (i.e. devoid of potential bias as associated with consensus-based mental state identification). Other than consensus ratings of 'correct' mental state identification, another frequently used method of achieving mental state classification is by getting targets' self-reports of their mental state labels, though this has been shown to be questionably accurate due to a myriad of factors, for instance the heterogeneity of mental state labelling and the diversity of people's understanding of mental states. The question remains, how can we better understand the mental state reasoning of those with ASD and how they utilise this knowledge to make sense of others' behaviours in the social world? A novel approach is introduced and evaluated in the following section.

2.4.2 Retrodictive mentalising

What does it mean to have a proficient ability to mentalise? A large body of research conducted with both neurotypical and people with ASD focuses on the ability to predict future behaviour as a vital indicator of mentalising ability. For instance, Senju, Southgate, White, and Frith (2009) tested 19 individuals with Asperger's disorder and 17 neurotypical individuals in a non-verbal false belief task involving spontaneous looking behaviour. Participants viewed an actor placing a ball into box A. Later a puppet is shown moving the ball into box B, unknown to the actor. Participants are then asked where the actor would look for the ball. Findings revealed that individuals with Asperger's did not show spontaneous anticipatory gaze behaviour toward the correct location (based on the actor's false belief) during the task while neurotypical participants did. However both groups successfully predicted the location of the ball when explicitly asked to do so. More examples of studies such as that outlined above have been reviewed in Chapter 1 and earlier in this chapter. Based on the literature reviewed, it is known that mentalising cannot be measured in its entirety through methods that have been used over the years such as behaviour prediction through first and second-order false belief tasks and mental state reasoning through emotion recognition tasks, which are often further constrained by potential limitations in language ability.

A relatively new method to investigate mentalising in an innovative way tests something called 'retrodiction' (Gallese & Goldman, 1998). In essence, retrodiction denotes one's ability to determine the precursors of a given mental state which is embodied in behavioural responses. This is predicated on the view that in the real-world, people do not frequently think about another person‘s mental state or know of their intention before the behaviour has occurred (Milikan, 2005). In contrast, retrodiction can be practically applied in real-life situations in which individuals often discriminate and understand mental states and behaviours in retrospect, after the behaviour has occurred.

Robinson and Mitchell (1995) first used retrodiction (though they did not call it that) to investigate mentalising in their study of 3-5 year olds who were told a story about identical twins. The story involved a ball being moved from one drawer to another, unknown to one twin (not in room at time of moving) but known to the other. The twins then leave the room and return shortly after looking for the ball, with one twin going to the correct new drawer and the other going to the original drawer. The children in the study were then asked why one twin went towards the original drawer looking for the ball. Results showed that children were able to infer successfully that the twin who went to the original drawer must be the person who was not present in the room when the ball was moved from its original location. This qualifies as an example of retrodiction because in order to answer the question, the child must explain observed behaviour by considering the protagonist's previous mental state - in this case lack of knowledge about the object's current position.

Now let us consider an example of retrodictive mentalising as follows. An employee is seen walking out of his superior‘s office after a meeting with a beaming smile on his face. Put into context, the employee‘s reaction could render several options as to what had just taken place within the office; a) He has just received a promotion; b) He has been awarded ‘Employee of the Month‘; c) He has been selected to represent the company in an important annual conference. The possibilities are endless even within the context, though the probable explanations for his behaviour are often congruent with the situation. However in real-life settings, situations and behavioural responses occur in a spontaneous fashion, short of being tightly wrapped within particular contexts. Hence people are required to decipher from a variety of possibilities the antecedent to an individual's response, bearing in mind the variety in different individuals' responses to the same situation.

Imagine now that short clips of people's behavioural responses during a meeting with their superior are presented to individuals and they are asked to infer what had taken place in the meeting. A choice of four possible antecedents are given; (a) informed that he or she is being considered for a job promotion; (b) told that his or her work performance has been unsatisfactory; (c) superior asks if he or she would be interested in going out on a date; and (d) asked to inform other staff members that certain internet sites (e.g. Facebook) will be banned from use during working hours. The range of behavioural responses resulting from the above mentioned four events could differ tremendously from person to person as each person may experience a variety of mental states. So how does one come to an accurate answer as to which event had occurred based on their brief observation of people's behaviour?

The reverse simulation framework developed by Goldman and Sripada (2005) offers an answer to this question involving retrodictive mentalising (see Figure 2.9). They proposed that the attributor processes his or her own mental state in the reverse direction. This is done in order to ascribe a mental state to the target which reflects the antecedent of the mental state which functions as evidence for the attribution. While it is known that the production of emotions can lead to distinguishing facial expressions (Ekman, 1992), Goldman and Sripada (2005) proposed that this relationship may also function in both directions. Evidence that the manipulation of facial musculature can produce an attenuated form of an emotional state has been supported by techniques such as holding a pen with one's teeth (produces a smile) as well as holding a pen with one's lips (produces a frown); which consequently has an influence on one's emotional state (Goldman & Mason, 2007). Hence the reverse simulation model proposes that the attributor first covertly mimics the facial expression of the observed target. As mentioned before, the mimicking of the facial expression normally results in the mild experiencing of that resultant mental state. The attributor then classifies his or her own mental state and subsequently ascribes the same state to the target.

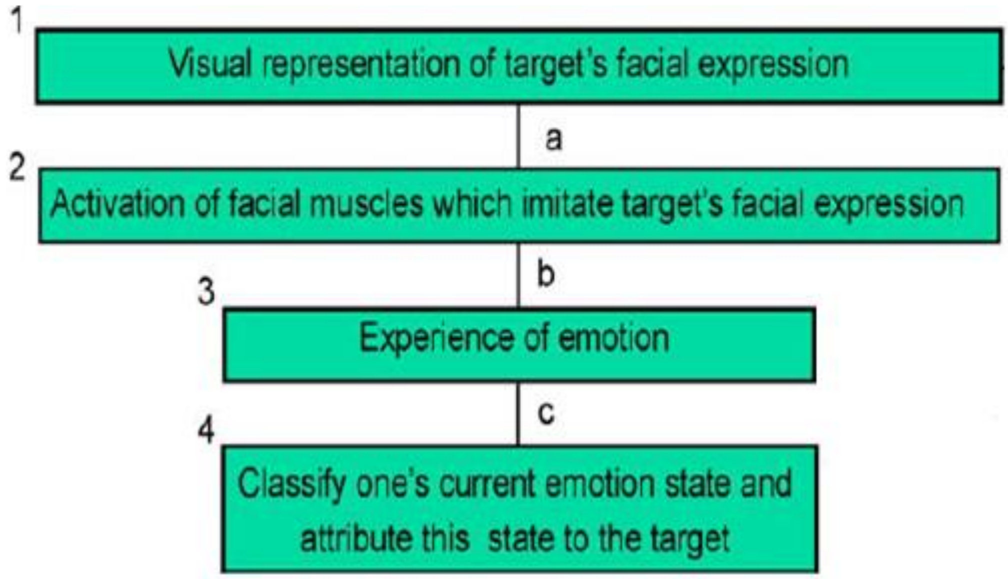

Figure 2.9: The reverse simulation model (adapted from Goldman & Sripada, 2005).

How would this framework apply to the meeting situation formerly described? In this case the attributor would mimic the target's facial expression (e.g. frown). The attributor then categorises his or her own mental state (e.g. disappointment) associated with that particular facial expression. The attributor then assigns this mental state to the target and subsequently uses it to retrodict the corresponding antecedent of the target's behavioural response (e.g. unsatisfactory work performance). The same process can be applied for the other situations. For instance a target's behavioural response may comprise a smile. The attributor then mimics the expression and classifies his or her own mental state as happiness. Subsequently, this mental state is attributed to the target and is used to retrodict to the most befitting antecedent event, in this case being the job promotion. Nonetheless the range of behavioural reactions (e.g. facial expressions) displayed by targets can be diverse. Being asked out on a date by a superior may cause some targets to feel confused and perhaps uncomfortable while others may feel pleasantly surprised. In the same line of thought, some targets might feel apprehensive while others may feel privileged that their superior has asked them to deliver the unpleasant news about restricted internet privileges to fellow colleagues.

In order to successfully retrodict which situation occurred to the person, the attributor assigns the most suitable precursor event to the assigned mental state of the target. The primary task used in this thesis involved individuals being presented with short clips of targets' natural reactions to four specific events (which will be referred to as scenarios). The scenarios were Joke, Waiting, Story, and Compliments. The genuine reactions to these scenarios were filmed during spontaneous interactions with the researcher. Individuals were asked to decide which of the four scenarios had occurred to the target. A comprehensive description of this task is described in Chapter 3. The paradigm used developed in this thesis allowed for the use of naturalistic and spontaneous expressions seen in everyday interactions rather than posed stimuli. Furthermore, individuals were not explicitly told to mentalise, though the method in which they come to the objectively correct answer (i.e. accurately identify the precursor scenario) does imply that retrodictive mentalising processes are being applied.

Though it has been shown that individuals with high-functioning ASD are able to perform as successfully as typically developing individuals in straightforward mental state recognition tasks, they often struggle with daily social interactions. As a result, the use of subtle and naturalistic stimuli in studies with this population is extremely relevant. Are people with ASD able to determine which scenario had just taken place by viewing short and spontaneous reactions of targets? This novel task (with an objectively correct response) efficiently investigates the ability of individuals with ASD to explain others' behaviours in a kind of backwards inference using true-to-life stimuli.

In addition it explores the degree to which people are able to use another person's reactions to 'view and experience' an event that they did not encounter first-hand. In the social world, it is essential that people have the ability to connect the observed with the unobserved by understanding the significance of behaviours through the process of inferring mental states. The faculty to mentalise is crucial, as without it the cause of observed behaviours may seem unclear and people's future behaviours become difficult to predict, making day-to-day communication with others challenging. As such an important question to ask is: is it fair to suppose that because individuals with ASD show impairments in predictive mentalising ability, so their capacity in retrodictive mentalising is also compromised?

2.5 Aims of thesis

The aim of the research described in this thesis was to create an experimental paradigm to study mentalising abilities in a way that closely approximates the subtleties of real-world situations. This new paradigm was used to examine mentalising abilities amongst healthy controls and individuals with ASD. Much research on mentalising has focused on the prediction of future behaviour; here, retrodiction was used to assess people's capacity to mentalise as it is believed that it is just as relevant in the social-world. Furthermore, eye gaze behaviours were investigated as there is currently conflicting evidence in regards to eye gaze patterns of individuals with and without ASD. Although much research has been conducted in examining the ability of people with ASD to recognise facial expressions and emotions, little is known about their capacity for portraying facial expressions. As a consequence the natural and spontaneous behavioural reactions of individuals with ASD were also investigated. Chapter 3 examined people's ability to guess what happened to others from their brief behavioural responses. In Chapter 4, the mentalising abilities of individuals with ASD compared to healthy controls were investigated. The experiments described in Chapters 3 and 4 also investigated participants' eye gaze patterns. Then in Chapter 5, people's mentalising ability was examined when viewing videoclips of individuals with ASD as well as healthy controls.

CHAPTER 3

Can Individuals Guess What Happened To Others From Their Brief Behavioural Responses?

EXPERIMENT 1

3.1 Introduction

When two people are engaged in social interaction, they each react to the behaviour of the other, and these reactions could manifest as humour, irritation, sympathy, bashfulness, to name a few. Can we guess what provoked a reaction just by observing a person's behaviour? If so, this might qualify as an instance of what Gallese and Goldman (1998) called 'retrodiction', which is a kind of backwards inference from a mental state to its causal antecedent. In this case, the mental state is embodied in a reaction (humour, irritation, sympathy, bashfulness, etc.). Can participants guess, for example, what caused a person to manifest irritation? If so, then participants would effectively have access to an aspect of the world through the lens of another person's mind (as embodied in behaviour). Indeed, the participants could perhaps learn something about a third party, by observing the effect the third party had on another person. This would be an important faculty in that participants could use other minds as a way of broadening their apprehension of the world – in this particular case, the social world. Apparently, this would qualify as a significant benefit of the participants' capacity for mentalising, or imputing mental states.

Currently, not much research uses tasks that have presented participants with a sample of behaviour and asked them to infer or to 'retrodict' the situation that resulted in that behaviour (although see Robinson & Mitchell, 1995 for an exception). Another aspect of understanding minds in the real world is that not all people will respond to the same situation in the same way (the diversity problem). One-to-one correspondence between situation and behaviour in real life is uncommon and we might assume that the mental states that mediate between situation and behaviour will also vary. Laboratory tasks that involve behavioural prediction tend to artificially generate one-to-one correspondence between situation and behaviour, ignoring this important feature. Paradigms are required that instead take account of this variability in responses with a view to discovering how we flexibly understand the behaviour of others, even where it departs from how we ourselves might act.

Some researchers have circumnavigated these issues by presenting participants with samples of behaviour (usually facial expressions) and asking them to identify the mental state of the individual concerned (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997) usually without any further inference to the antecedent situation. Proponents of this approach have argued that mental states (such as admire, thoughtfulness, scheme) can be directly observable from facial expressions. They also argue that in our everyday lives we understand the mental states of others through a combination of high-level and low-level mentalising processes. High-level processes involve reasoning in a "top-down" fashion about mental states based on our prior knowledge of the relationships between mental states and situations. For example, based on our prior knowledge about the relationship between what a person sees and what they know, we might reason that someone has a false belief about an object being in a particular location because that individual did not witness it being moved elsewhere. In contrast, low-level mentalising processes involve "bottom-up" recognition of cues or indicators such as eye gaze behaviour or facial expressions (Baron-Cohen et al., 1997). The mechanisms for these two processes may well be different: mirror neurons have been proposed as a possible basis for low-level mentalising processes, while high-level mentalising is more likely to be grounded in a propositional (non-bodily) format (Goldman & Vignemont, 2009). Retrodictive mindreading as described above might involve a combination of these processes. We may well recognise and decode the behaviour via a bodily format of representation, a relatively low-level process. However, this must be at some point integrated with some prior knowledge of situations that may give rise to that kind of feeling.

The stimuli used in studies involving identifying mental states from facial expressions have also been criticised for the following reasons. In real life, the behaviour we are trying to understand may be subtle. For example, facial expressions are often dynamic and brief. Most studies have not taken these considerations into account and have tended to portray static images of emotional responses, often displayed for several seconds (Ekman & Friesen, 1976). As the expressions in such studies are posed by actors, the “correct” answer as to what that person is thinking or feeling is usually determined by consensus of viewers and may bear no relation to the actual mental state of the actor in question. As no event or situation in the world has given rise to the expression (other than the actor being asked to pose by the researcher), it is unclear how well results of such studies can inform us about the processes we use when reasoning about the relationship between an event or situation and observable behaviour.

In recognition of this last point some researchers have developed more naturalistic stimuli where expressions have either been induced or recorded in a real-world setting. For example, Matsumoto, Olide, Schug, Willingham, and Callan (2009) used facial expressions of athletes, captured at the end of Olympic Judo matches. While we can be more confident that the individuals reacting in studies such as this are experiencing some kind of mental state, a problem remains in knowing the correct answer. Even if the individual him/herself is asked what he/she was thinking or feeling we cannot know for certain whether the verbal report is an accurate representation of the mental state experienced. Besides, the individual may feel a blend of emotions, thoughts, desires and so on, many of which cannot easily be described in words. It may also be that it is easier to perceive or interpret the behaviour of an individual than to generate a mental state label that adequately captures an impression of his or her experience. Moreover, the very act of trying to verbalise what another person might be thinking or feeling could interfere with our ability to spontaneously interpret their behaviour in context.

Concerns about difficulties associated with naming mental states (in this case, belief states) were taken into consideration by Wimmer and Perner (1983) when they devised the now widely known unexpected transfer test of false belief, in which child participants are invited to predict where a protagonist will search for chocolate (and are not asked to make any direct inferences about the protagonist's belief state). In this task, participants must reflect on the belief state of the protagonist in order to predict his/her behaviour, but are not required to name or refer to any belief state directly. While that research undoubtedly represented a major breakthrough, it is open to the criticisms mentioned previously (i.e. one-to-one correspondence between situation and behaviour).

The studies reported in this chapter include a paradigm that approximates many of the demands of real life situations where mental state reasoning might be required, and addresses some of the criticisms that might be levelled against previous research. Participants were shown people's natural (and somewhat subtle) reactions to four specific scenarios, all of which were filmed during an interaction with the researcher, and asked to identify which of the four events had previously occurred. To succeed at this task, it is necessary to retrodict, that is, to reason backwards from behaviour to infer a situation that had already happened. Participants were not asked to identify the mental state of the individuals explicitly, thus overcoming any concerns about their being able to verbalise or label their inner subjective states and also avoiding the possibility of "instructing" participants to use a mentalising strategy. Instead, participants were required to identify the situation, about which there was a definite objectively correct answer. If a small sample of behaviour is sufficient for people to get a feel for what circumstance may have led to that behaviour, then it is predicted that participants would systematically identify which of the four specific scenarios had previously occurred to the people in the videos that they viewed.

Participants' eye movements were also recorded while viewing the videos. Previous research has suggested that when viewing static images containing people, individuals look more at the eye region compared to the rest of the face (Hernandez et al., 2009). Also, when freely viewing videos containing people, both adults (Klin, Jones, Schultz, Volkmar, & Cohen, 2002) and young children (Jones, Carr, & Klin, 2008) tend to spend the majority of their time looking at the eye region of the face. Moreover, the eye region may convey crucial information for tasks that involve trying to name emotions or mental states from images of faces (Baron-Cohen et al., 1997). Given the importance of the eye region that is documented in previous research, it was predicted that participants would spend more of their time looking at the eye region than the mouth region of the faces of the people in the videos. Another prediction was that total eye region gaze time would be negatively correlated with total mouth region gaze time, consistent with the findings of Kirchner, Hatri, Heekeren, and Dziobek (2011). It was also hypothesised that time spent looking at the eye region would correlate with successful identification of the scenario that had previously occurred. In other words, it was predicted that participants who spent more time looking at the eye region when viewing the reaction videoclips would have the greatest success in identifying the scenarios. It was further hypothesised that this relationship would hold for each of the scenarios i.e. it was predicted that the amount of time spent looking at the eye region when viewing a particular scenario would positively correlate with identification of that scenario.

Empathy has been described as the "capacity to understand others and experience their feelings in relation to oneself" (Decety & Jackson, 2004, p.71). The multifaceted construct of empathy has generally been viewed as consisting of two fundamental elements; *affective* and *cognitive.* The affective element relates to individuals' emotional *responses* to the mental states of others, whereas the cognitive element concentrates on individuals' *understanding* of the mental states of others (Chakrabarti & Baron-Cohen, 2006). Furthermore, the cognitive component of empathy has been associated with the concept of mentalising. Baron-Cohen and Wheelwright (2004) proposed that empathy is crucial in the understanding of others' intentions, in predicting their behaviours, and in having insight and awareness into their emotions. Hence, the use of an instrument such as the Empathy Quotient (EQ; Baron-Cohen & Wheelwright, 2004) would in essence tap into one's mentalising abilities. Therefore, the present study also predicted that empathising ability as measured by the EQ will positively relate with success in scenario discrimination (i.e. retrodiction). This may be associated with greater looking to the eye region in those with high empathic abilities; consequently it is hypothesised that eye region gaze time would be positively correlated with EQ scores and positively related with the ability to infer what happened to the person in the video. It was further predicted that the EQ scores of the people in the reaction videoclips would be associated with participants' ability in correctly identifying the scenarios.

3.2 Methods

The study was divided into two parts; Stimulus Development and Main Experiment. The procedure was approved by the Ethics Committee, School of Psychology, University of Nottingham.

3.2.1 Stimulus Development

The literature review in Chapter 1 and Chapter 2 summarised the various studies that have investigated mentalising, each with their respective strengths and limitations. The objective of this phase of the study was to develop a procedure which examines mentalising in a novel manner, whilst taking into account the shortcomings of previous work. An often mentioned drawback of mentalising research is its lab-based nature and how well the findings translate to real-world situations. Few studies have investigated people's mentalising abilities in an ecologically valid social context (e.g. Matsumoto et al., 2009). The task of identifying mental states during a face-to-face interaction or watching videos of naturalistic social scenes can be complex as multiple factors come into play. One must be able to incorporate body language cues, and aspects of social context while concurrently processing dynamic stimuli.

Additionally, encounters in real-life often consist of subtle and brief reactions, as opposed to exaggerated and posed reactions frequently used in research. Participants in this project were shown people's natural and subtle reactions to four specific scenarios. Though the primary focus of the four scenarios was to draw out an assortment of responses from participants, the concept of social emotions was also considered. Burnett, Bird, Moll, Frith, & Blakemore (2008) stated that the representation of other people's mental states is necessary in order to recognise and comprehend social emotions such as pride, embarrassment, shame and jealousy. Hence several events were created with foresight that people's responses could embody forms of social emotion. Reactions to the four scenarios were filmed during an interaction with the researcher, and participants in the main study were asked to determine which of the four events had previously occurred; the task is useful with respect to Gallese and Goldman's (1998) concept of 'retrodiction' i.e. to reason backwards from the presented behaviour to deduce an event that occurred in the past. This method is advantageous as it overcomes difficulties related to asking participants to name mental states as there is an objectively correct answer.

The following section describes the Stimuli Development phase of the study. The experiments in the following two chapters of this thesis all included stimuli that were generated according to the general methods outlined below (any differences in methodology will be highlighted in the respective chapters).

Target Reaction Videoclips

Participants (henceforth known as 'targets') were told that they would be filmed whilst posing some facial expressions to act as stimuli for a different study. However, the primary focus was actually to record targets' responses to an apparently incidental event that occurred prior to commencing the recording of the posed expressions.

Targets

Forty students from the University of Nottingham (United Kingdom and Malaysia Campus) were recruited. A total of 19 males and 21 females across both campuses aged between 19 and 34 were filmed (mean age= 22.2 years). Targets were of various nationalities; 16 Malaysians, 12 British, 1 Spanish, 1 Vietnamese, 1 Sri Lankan, 1 Botswanan, 1 Indian, 1 Italian, 1 Irish, 1 Nigerian, 1 Polish, 1 Chinese, 1 Ugandan; and 1 Lithuanian. The targets from the Malaysian campus were given an inconvenience allowance in the form of chocolate whereas the targets from the UK campus were given three pounds each for their participation. Written informed consent was obtained from all targets.

Materials and Apparatus

A spacious room was utilised for testing within the School of Psychology. Targets were seated with their backs against a while wall, towards the main door and windows. The researcher was seated across the table from the target participant.

A Sony DCR-TRV460 video camera was used to film the targets during the experiment. The camera was positioned approximately 1.7 meters from the targets' seats and was placed directly next to the researcher on a tripod. The camera was positioned in order for the target participants' face, neck, shoulders, and chest to be seen.

The Empathy Quotient (EQ; Baron-Cohen & Wheelwright, 2004, see Appendix A), a standardised testing instrument was distributed to the targets at the end of the experiment. The EQ is reported to have good construct and external validity as well test-retest reliability (Baron-Cohen & Wheelwright, 2004). It comprises 40 questions with four-option forced choice response format (strongly agree, slightly agree, slightly disagree, strongly disagree). The target participants were given as much time as they required to complete the questionnaire.

Experimental and Filming Procedure

Targets were invited to partake in the experiment and were told that they would be filmed posing specific facial expressions which would be used as video stimuli in a subsequent study. Four scenarios were created, one of which was performed by the researcher to each target participant. The scenarios were devised with a view of eliciting a range of responses from targets. The primary focus was to create scenarios that would provoke a reaction but would be unlikely to cause a major disturbance in the mood of the targets. The scenarios also needed to be plausible within the context of an experiment, as it was important that the targets did not guess that the researcher was in fact following a script.

The four different scenarios were randomised between targets. Each target experienced only one of these scenarios. Descriptions of each scenario are listed below:

<u>Scenario 1 (Joke)</u>: As the target was ready and awaiting the start of the experiment, the researcher initiated a casual chat with him/her. The researcher then shared a simple joke with the target. The joke is listed below:

"Why did the woman wear a helmet at the dinner table? Because she was on a crash diet!"

Scenario 2 (Waiting): As soon as the target entered the testing room, he/she was given the information statement and consent form. Once complete, the researcher stated that they would begin the experiment soon. However, the researcher kept the target waiting for about 5-8 minutes whilst she performed other irrelevant tasks (i.e. making a phone call, texting on mobile phone, having a drink of water) while seated in front of the target.

Scenario 3 (Story): As the target was ready and waiting to start the experiment, the researcher chatted with him/her and related a story about a series of misfortunes that she experienced earlier that day. The researcher related minor 'everyday' misfortunes such as *missed the bus to university, left mobile phone at home, starts raining and not having an umbrella,* and *flashdrive containing important work malfunctions.*

Scenario 4 (Compliments): As the target was waiting to start the experiment, the researcher gave instructions regarding the experiment. While doing so, the researcher offered a series of compliments. Examples are:

i. *Really nice pair of earrings you have there*
ii. *You've got really good hair, what shampoo do you use?*
iii. *That shirt really brings out the colour of your eyes*!
iv. *Wow, your skin is so smooth and radiant. What moisturiser do you use?*

As the real aim was to record targets' immediate responses to the four scenarios, the video camera was set to record as soon as targets were seated; they were unaware that the camera was recording at this stage. They were under the impression that the video recording would only begin during the posing of facial expressions.

At the completion of any one of the four scenarios mentioned above, targets were then asked to look directly at the video camera and to form six facial expressions *(surprise, happy, fear, anger, sad, disgust).* The facial expression words were then dictated by the researcher in the same order each time. As the targets were unaware that filming had already begun, the researcher pretended to switch on the camera prior to dictating the facial expression words. Once the targets had completed posing the six facial expressions, the researcher turned off the video camera. The targets then completed the EQ questionnaire.

Prior to leaving the testing room, targets were debriefed about the true nature of the study and were given the opportunity to ask any questions in regard to the experiment. Targets' consent to use the video recording of their reactions to the researcher in Scenario 1-4 was obtained. One target participant did not provide consent; hence the related video recordings were destroyed immediately (this target is not included in the 40 stated above).

Editing

The footage was transferred from the video camera to an Apple Macintosh computer and edited using video-editing software, iMovie HD 6. The videoclips were edited to capture targets' reactions to the distinct scenarios at points where they were deemed to be most expressive (see Figure 3.1). Due to the naturalistic and temporally distinct context of the scenarios, there was no clear way of determining a definite start and end point to each reaction as every individual responded uniquely to the varying scenarios. This opened up the possibility of experimenter bias in picking the most stereotypical responses as the editor was not blind to the scenarios when viewing and editing the videoclips. Nevertheless, most of the videos captured responses around the end of the scenario enactment. The 40 edited videoclips (10 for each scenario) ranged from 3.64 to 8.96 seconds, based on the dynamic nature of the targets' natural responses with the respective means being Joke: 6.59 (SD=.26); Waiting: 6.84 (SD=.23); Story: 6.86 (SD=.37); Compliments: 5.81 (SD=.40). A one-way ANOVA showed that the clip length did not vary systematically with the scenarios (p=.116). Video frames were 720 pixels in width and 576 pixels in height. The rate of presentation was 25 frames per second. The edited clips omitted the audio component as targets' verbal responses would have completely disambiguated the reactions in many cases.

Figure 3.1: Sample screenshots of target reaction videoclips.

Scenario Enactment Videoclips

These videoclips were created in order to convey what the targets had experienced in the Stimulus Development phase of the study.

Filming Procedure

The researcher was filmed using a Sony DCR-TRV460 video camera in a quiet room within the School of Psychology. The researcher looked directly at the camera and acted as though addressing the targets from the Stimulus Development phase. The camera was positioned in order for the researcher's face, neck, shoulders, and chest to be seen.

Editing

The footage was transferred from the video camera to an Apple Macintosh computer and edited using video-editing software, iMovie HD 6. The videos were further edited using VirtualDub (v1.9.10), a video capture and video processing software. VirtualDub was used to create coloured borders for each scenario clip; Scenario 1 (Joke)- Green border, Scenario 2 (Waiting)- Red border, Scenario 3 (Story)- Blue border, and Scenario 4 (Compliments)- Yellow border (see Figure 3.2). The coloured borders were 0.5 centimetres in width. Each clip varied in length according to the content of the social scene; Scenario 1 (Joke)- 11 seconds, Scenario 2 (Waiting)- 89 seconds, Scenario 3 (Story)- 34 seconds, and Scenario 4 (Compliments)- 27 seconds. These variations in length were inevitable because of the dynamics of the encounters themselves; the implications of this will be discussed later. Video frames were 720 pixels in width and 576 pixels in height. The rate of presentation was 25 frames per second. The bit rate for the audio track was 352 kbps.

Figure 3.2: Sample screenshots of scenario enactment videoclips.

Materials

To correspond with the scenario enactment videoclips with coloured borders, four matching flashcards with the dimensions 10 centimetres x 14 centimetres were created with borders of the same colours. The names of each scenario (*Joke, Waiting, Story, Compliments*) were printed in black font on white background. The coloured borders on the flashcards were approximately 0.5 centimetres in width and were used to aid memory for the scenarios enacted by the researcher. Only the scenario clips and flashcards had corresponding coloured borders to aid memory recall; the 40 target reaction videoclips did not have coloured borders. The coloured borders in the scenario clips and flashcards could have influenced participants to respond a certain way, e.g. to pick the Waiting scenario more often because they liked the colour red. However, this would result in a higher false alarm rate, which is taken into account by *d*-prime calculation explained in the Results section.

3.2.2 Main Experiment

Participants

Thirty-five participants (19 males and 16 females) aged between 18 and 35 (mean age= 22.37 years) took part in this phase of the study. The experiment was conducted at the University of Nottingham (United Kingdom and Malaysia campus). Participants were of various nationalities: 19 Malaysians, 7 British, 3 Sudanese, 1 Dutch, 1 Japanese, 1 Singaporean, 1 Indonesian, 1 Tanzanian, and 1 Chinese national. All were paid an inconvenience allowance and written informed consent was obtained.

Materials and Apparatus

The previously described scenario enactment videoclips and 40 target reaction videoclips from the Stimulus Development phase of the study were used. All videoclips (scenario enactment as well as targets' reactions) were shown on a 17 inch TFT monitor incorporated into the Tobii T60 Eye Tracker (data rate 60 Hz). The 40 stimuli were shown using Tobii Studio Analysis Software. The software randomised the presentation of the videoclips. Each videoclip was interspersed with an image of a fixation point (white central cross on a black background located at the centre of the screen). The fixation point remained on screen until the participant responded to the previously presented videoclip. The Tobii T60 Eye Tracker was used to record participants' looking behaviour. Participants also completed the EQ questionnaire. IBM SPSS statistical analysis software was used to analyse the data in this thesis.

Design

A within-subjects design was used, where all participants viewed the four scenario enactment videoclips followed by the 40 target reaction videoclips.

Procedure

Participants were tested individually in a quiet room. All video stimuli were presented to participants on the eye tracker screen. Participants sat approximately 60 centimetres from the monitor and the video stimuli subtended a horizontal visual angle of 22.5° and a vertical visual angle of 11.4°. The videoclips of the researcher enacting the four scenarios were first shown to the participants. The scenarios were presented in counterbalanced order and were only shown once to participants at the start of the experiment. After the presentation of each scenario enactment videoclip, the corresponding flashcard for the scenario was shown to the participants and placed on the table in front of the monitor. The flashcards were thus displayed in the same counterbalanced order as the scenario videos had been presented. Presenting these scenario clips allowed participants to experience as closely as possible the experience of the participants in the Stimulus Development phase. As a result, participants had a clear understanding of what each scenario entailed, with both audio and visual information presented. Prior to the start of the experiment, a 9-point calibration procedure was conducted in which a moving red dot appeared in different locations on the screen, including the centre, the four corners and the mid-points in between. Participants were required to follow the red dot with their eyes as it moved around the screen enabling the eye tracker to obtain baseline data with which to compare subsequent eye movement recordings. Following successful calibration, participants were then shown the 40 target reaction videoclips. The presentation of the videoclips was randomised via Tobii Studio Analysis Software. Participants were told to direct their gaze at a central fixation point prior to the presentation of each of the 40 videoclips, which was controlled via a mouse-click by the researcher. After the clip was shown, the fixation point reappeared and participants were required to state which scenario they thought the person in the video was reacting to by either verbalising or pointing, using the flashcards as cues. The researcher asked a question each time "Which of these events had just happened?" and then briefly reminded the participants of the four options verbally (i.e. in the same counterbalanced sequence that the scenario enactment clips and flashcards were presented previously), while pointing to the flashcards: "Is it the joke, waiting, the story, or compliments?" The researcher recorded participants' responses on a data sheet. This process continued for all 40 videoclips. The participants then completed the EQ questionnaire.

3.3 Results

3.3.1 Were participants able to correctly identify the scenarios which targets reacted to?

The primary question was whether participants could discriminate between reactions to the four scenarios. Responses were analysed using a signal detection procedure to account for any bias in responding with a particular scenario. This generates an index *d*-prime (*d*'), from the hit rate (the proportion of occasions on which the participant correctly identified the scenario) and false alarm rate (the proportion of occasions on which the participant identified the scenario when it was the incorrect answer). In this experiment, the hit rate was calculated for the ten trials comprising a particular scenario, while the false alarm rate was calculated across the remaining thirty trials which did not comprise that scenario. The Snodgrass and Corwin (1988) correction factor was applied to the hit and false alarm rate calculations to correct for cells containing 0, by adding 0.5 to all cells. *d*' is then calculated by subtracting the *z*-score for the false alarm rate from the *z*-score of the hit rate [$d' = Z(\text{hit rate}) - Z(\text{false alarm rate})$ where function $Z(p)$, $p \in [0,1]$, is the inverse of the cumulative Gaussian distribution. *d*' is a measure of the distance between signal and noise distributions and is essentially an indicator of how well participants were able to correctly discriminate each scenario from the others. Table 3.1 displays the mean accuracy rates, false alarm rates and *d'* scores for targets' reactions to the four scenarios. If participants did not systematically discriminate the correct scenarios that the targets were reacting to, the hit rate would be equal to the false alarm rate and their *d'* score would be 0. *d'* scores were significantly greater than 0 for reactions to all four scenarios [Joke $t(34)=12.61$, $p<.001$; Waiting $t(34)=20.83$, $p<.001$; Story $t(34)=12.87$, $p<.001$; Compliments $t(34)=10.51$, $p<.001$], indicating that participants were able to discriminate between them in a systematic manner.

	Accuracy	False alarms	*d'* (*d*-prime)
Joke	4.54 (45.4%)	3.69 (12.3%)	1.06
Waiting	9.00 (90.0%)	3.66 (12.2%)	2.49
Story	5.66 (56.6%)	3.86 (12.9%)	1.32
Compliments	5.11 (51.1%)	4.49 (15.0%)	1.05

Table 3.1: Participant mean accuracy rates, false alarm rates and d' scores. (correct scenario discriminability).

Accuracy : Number correct out of 10 (% in brackets)

False alarm: False alarms out of a possible 30 (% in brackets)

To establish if there were differences between reactions to the scenarios in participants' level of success, a one-way repeated measures ANOVA was conducted on the *d'* scores, with scenario as the within-participants factor. There was a main effect of scenario, $F(3,102)=87.87$, $p<.001$, Cohen's $f = 2.73$ (large effect; Cohen, 1988). Posthoc *t*-tests with Bonferroni correction showed that this was due to reactions to the Waiting scenario being easier to discriminate than reactions to the other three scenarios (all *ps*<.001). Reactions to the Story scenario also approached significance in being easier to discriminate than reactions to the Compliments scenario (p=.056).

Chi-square analyses were then conducted to investigate participants' pattern of error responses. Four separate chi-square analyses were performed for each scenario. Table 3.2 shows frequencies of participants' error responses. Findings showed that participants' error responses were not equally distributed for the Joke [$X^2(3, n= 188) = 30.71, p <.001$] scenario, with participants primarily mistaking reactions to the Joke for reactions to Compliments. Their errors were also not equally distributed in the Waiting scenario [$X^2(3, n= 35) = 7.26, p =.03$] with them mistaking it most often for reactions to the Story scenario. Furthermore, participants' errors were not equally distributed for the Compliments scenario [$X^2(3, n= 163) = 8.63, p =.01$], which participants mainly mistook for reactions to the Joke scenario. On the other hand, participants' errors for the Story scenario were equally distributed across the three remaining options [$X^2(3, n= 151) = 2.16, p =.34$].

	Joke	Waiting (observed error responses)	Compliments	Story	Expected error responses
Joke	-	31	93	64	62.67
Waiting	12	-	5	18	11.67
Compliments	72	45	-	46	54.33
Story	42	53	56	-	50.33

Table 3.2: Participant error response distribution (in frequencies).

3.3.2 What were participants' eye gaze patterns and do they relate to correct scenario identification?

The purpose of the eye tracking analyses was to determine whether participants' ability to discriminate reactions to the various scenarios was associated with looking at specific parts of the scene. The eye-tracking data were processed using Tobii Studio 3.0's dynamic areas of interest (AOIs) function. This allows one to create AOIs that move and change shape with the movements of objects in the video (see Figure 3.3). In order to calculate eye movement metrics, AOIs were defined separately on the eye and mouth regions of the video stimuli. The Total Fixation Duration (seconds) metric was used to measure the total duration for all fixations within a) the eye region, and b) the mouth region. Fixation is defined by the standard Tobii fixation filter as two or more consecutive samples falling within a 35 pixel radius.

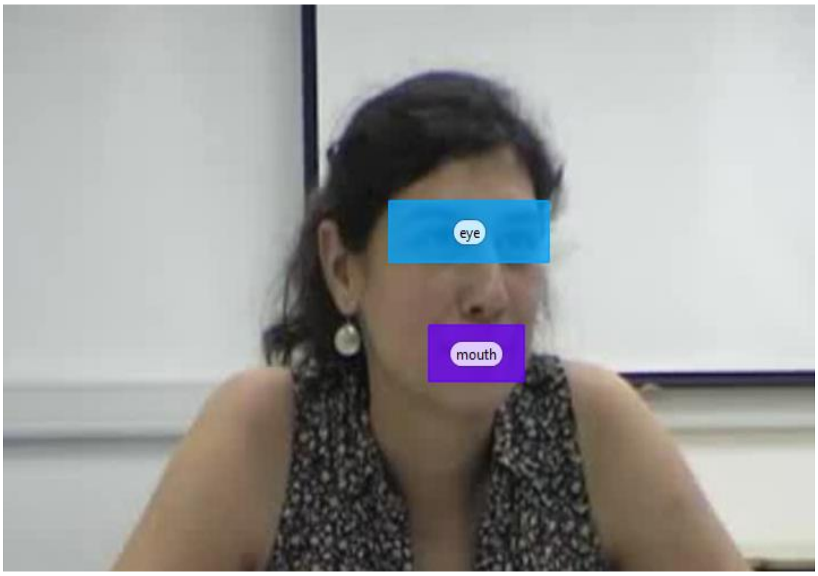

Figure 3.3: Sample area of interest (AOI) used to analyse eye gaze.

Figure 3.4 shows the mean gaze time for the eye and mouth (as a percentage of total gaze time) for each of the four scenarios (please note that the standard errors bars in the figure reflect between-subject variance, and are therefore not suitable for assessing within-subject comparisons).

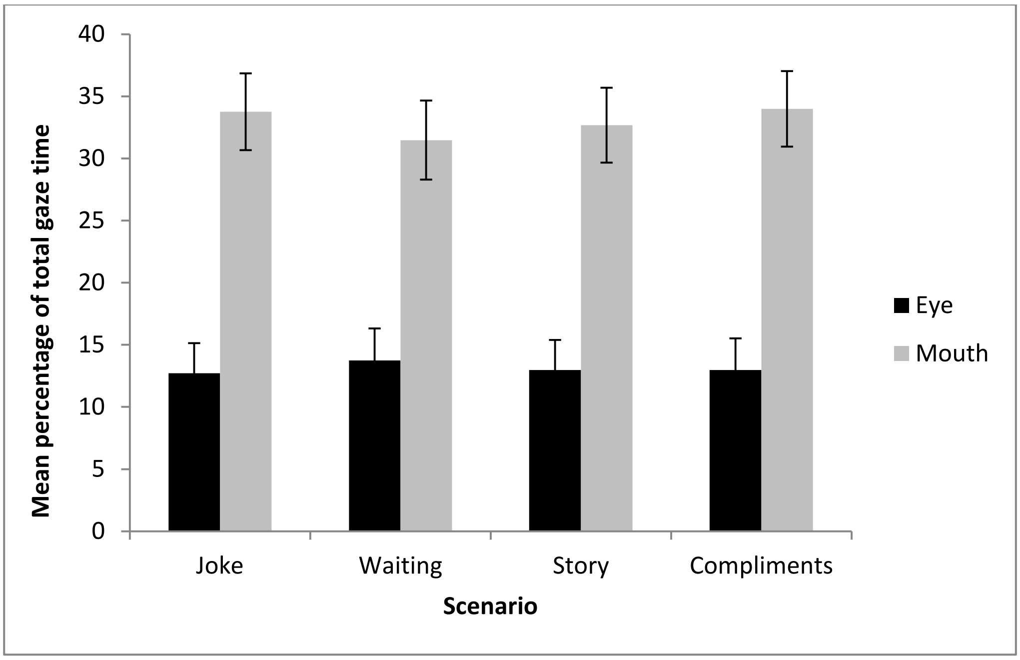

Figure 3.4: Mean percentage of total gaze time at the eye and mouth regions of targets across four scenarios.
(Error bars represent standard errors of the mean)

As the videoclips varied in length, the percentage of gaze time spent on the eyes and mouth regions for each clip was used (i.e. time spent looking at eye/mouth region ÷ total gaze time * 100%). As the data were not normally distributed (i.e. Shapiro-Wilks tests showed that gaze time at the eye region was not normally distributed for targets in all 4 scenarios, all *ps*<.001. This was due to mild positive skew with all values >.14), the data were transformed using a square root transformation for the purpose of analysis (untransformed means are reported for the ease of interpretation). Following transformation, the data were normally distributed (Shapiro-Wilks *p*>.1). A repeated measures ANOVA was conducted on gaze time, with scenario (Joke, Waiting, Story, Compliments) and region of the face (eyes or mouth) as within-participants factors. Scenario was included as a factor due to the possibility that participants might have used different viewing strategies for reactions to the different scenarios. While the effect for scenario approached significance (p =.065), there was a significant effect for face region, $F(1,34)= 17.51$, $p < .001$, Cohen's f = .69 (large effect), whereby participants spent longer looking at the mouth region (*M*=5.47, *SD*=1.77) than the eye region (*M*=2.97, *SD*=2.10). This was qualified by a significant interaction between scenario reacted to and face region indicating that gaze time to the critical regions (eyes and mouth) did vary depending on the scenario the target was responding to, $F(3, 102)= 13.06$, $p < .001$, Cohen's f = 1.02 (large effect) [see Figure 3.5].

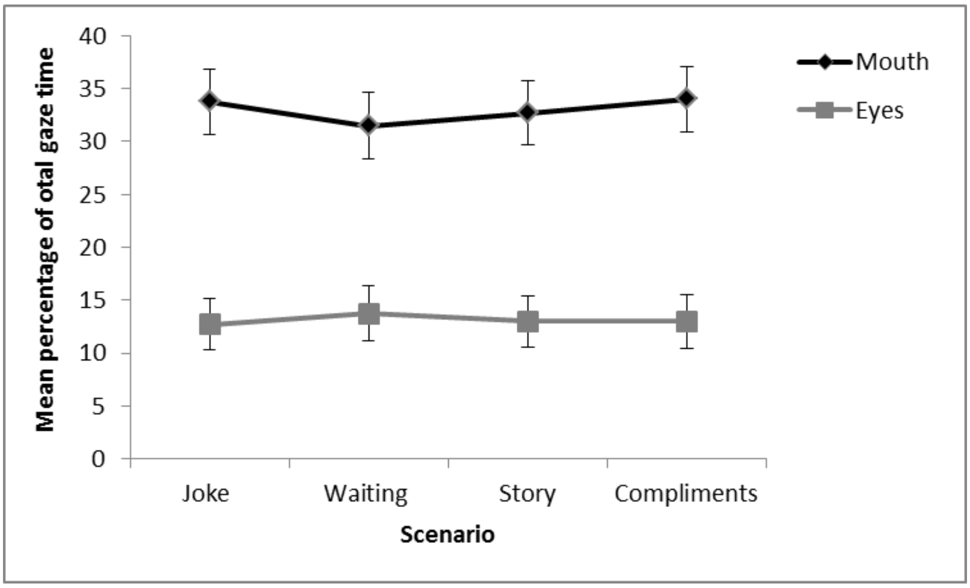

Figure 3.5: Interaction between face region and scenario for gaze time.
(Error bars represent standard errors of the mean)

Further analyses were conducted to establish the basis of this interaction. Separate one-way ANOVAs examined the effect of the scenario the target responded to on gaze time at the eyes, and the mouth. There was a significant effect of scenario on time spent looking at the eye region, $F(3,102)= 5.05$, $p =.018$, Greenhouse Geisser corrected, Cohen's f = .59 (large effect). Posthoc *t*-tests with Bonferroni correction revealed that participants spent more time looking at the eye region for targets in the Waiting scenario compared with the Story ($p = .006$) and Joke scenarios ($p = .005$). Similarly, there was a significant effect of scenario reacted to on time spent looking at the mouth region, $F(3,102)= 11.46$, $p < .001$, Greenhouse Geisser corrected, Cohen's f = .95 (large effect). Posthoc *t*-tests with Bonferroni corrections revealed that participants spent more time looking at the mouth region of targets in the Joke (*p* = .004), Compliments (*p* = .001), and Story (*p* = .011) scenarios compared with the Waiting scenario.

Due to the Waiting scenario being easier to identify than the other three scenarios and due to its being associated with different eye gaze patterns, it was analysed separately from the other three scenarios when examining the relationship between gaze patterns and scenario identification. This was to ensure that any apparent relationships were not solely driven by performance in this particular condition. As predicted, it was found that total time spent looking at the eye region negatively correlated with total time spent looking at the mouth region for targets in the Waiting scenario (r=-.7, n=35, p< .001). Similar findings were revealed for the remaining three scenarios with participants who spend more time looking at the eye region having a tendency to look less at the mouth region (r=-.69, n=35, p< .001).

Do variations in gaze pattern relate to accuracy in detecting the scenario? Overall there was a significant negative correlation between mean eye region gaze time and mean *d'* scores (correct scenario discriminability) across targets reacting to the remaining three scenarios, r = -.44, n =35, p=.008, suggesting that individuals who spent more time looking at the eye region in general were less successful at discriminating between the scenarios which targets were responding to. The relationship between mean mouth region gaze time and mean *d'* scores was not significant, r=.15, n=35, p=.385, indicating no evidence of any relationship between looking at the mouth and successfully discriminating between the scenarios. The same relationships were also investigated for targets responding to each scenario individually. In other words, gaze time to the eye region for targets in each scenario and its relation to the *d'* scores for the same scenario was examined. Eye region gaze time correlated negatively with *d'* for targets in the Compliments scenario (r=-.34, n=35, p=.032) and the Story scenario (r=-.44, n=35, p=.008) and the Waiting scenario (r=-.45, n=35, p=.006), but not for targets in the Joke scenario (*r*=.02, n=35, *p*=.912). There were no significant relationships between gaze time at the mouth region and *d*' for targets in any of the four scenarios.

3.3.3 Were participants' EQ scores related with their eye gaze behaviours and ability to discriminate between the scenarios targets reacted to?

Participants' mean EQ score was 43.85 (*SD*=8.7) and thus similar to the normative value of 42.1 (Baron-Cohen & Wheelwright, 2004). Are participants with higher EQ scores better able to discriminate between reactions to the scenarios? Four separate Pearson product-moment correlations with Bonferroni adjusted alpha level of .0125 were conducted. No relationships were found between correct scenario discrimination and participant EQ scores for reactions to all four scenarios (Joke: *r*= -.04, n=35, *p*=.862; Story: *r*= .20, n=35, *p*=.263; Compliments: *r*= -.01, n=35, *p*=.944; and Waiting: *r*= .36, n=35, *p*=.042).

Are variations in participants' eye gaze patterns associated with their EQ scores? It was found that there was no significant relationship between eye region gaze time and participant EQ scores (*r*= -.09, n=35, *p*=.621). The same finding was obtained for mouth region gaze time and EQ scores (*r*= .26, n=35, *p*=.134). No relationships were found for time spent looking at the eye and mouth regions and participant EQ scores across reactions to all scenarios [Bonferroni corrected] (Joke Eye: *r*=-.08, n=35, *p*=.647; Story Eye: *r*=-.09, n=35, *p*=.595; Compliments Eye: *r*=-.08, n=35, *p*=.673; Waiting Eye: *r*=-.12, n=35, *p*=.513; Compliments Mouth: *r*=.26, n=35, *p*=.142; Joke Mouth: *r*=.29, n=35, *p*=.095); Story Mouth: *r*=.30, n=352, *p*=.086; and Waiting Mouth (*r*=.32, n=35, *p*=.061).

3.3.4 Did the EQ scores of targets affect participants' ability to deduce what had happened to them?

It was then examined whether the EQ scores of targets (i.e. people in the reaction videoclips) were associated with participants' ability to correctly identify the scenarios they were reacting to. It was postulated that an alternative factor that may drive success in this task is the expressiveness of the targets in the reaction videoclips. One might think that people who have a higher EQ score and are more emotionally attuned to others might themselves be more expressive than those of lesser EQ scores. Table 3.3 shows the targets' mean EQ scores and participant accuracy rates broken down by scenario they responded to. The accuracy rates describe the percentage of participants who successfully identified the scenario the target was reacting to from the videoclips ([number of participants who correctly identified the scenario experienced by the target in the videoclip ÷ 35] * 100). There were a total of 40 videoclips (i.e. 10 videoclips for each of the 4 scenarios) with 19 males and 21 females being filmed in the videos.

	EQ scores	Accuracy (in percentage)
	Mean (*SD*)	Mean (*SD*)
Joke	38.7 (10.22)	46.0 (25.25)
Waiting	33.7 (12.94)	90.0 (4.52)
Story	50.2 (5.49)	56.57 (17.34)
Compliments	42.9 (9.52)	51.29 (24.29)

Table 3.3: Targets' mean EQ scores & participants' accuracy rates.

First, a one-way between groups ANOVA was conducted to explore whether there were differences in EQ scores of targets experiencing the different scenarios. As targets were allocated to the four scenarios in an unbiased manner, it was expected that no difference in EQ scores would be found for those experiencing each scenario. However, there was a statistically significant difference in EQ scores between scenarios ($F(3,36)=4.97$, $p=.006$). Posthoc *t*-tests with Bonferonni correction showed that targets in the Story scenario had significantly higher EQ scores than targets in the Waiting scenario ($p=.004$).

Then the relationship between the EQ scores of the targets and participants' abilities in correctly detecting the scenario reacted to was investigated separately for responses to each scenario using a Pearson product-moment correlation coefficient (with Bonferroni adjusted alpha level of .0125). No significant relationships were found between target EQ and accuracy scores in all scenarios (Waiting: $r=-.02$, $n=10$, $p=.944$;. Story: $r=.10$, $n=10$, $p=.782$; Joke: $r=.67$, $n=10$, $p=.035$; and Compliments: $r=.69$, $n=10$, $p=.033$).

3.4 Interim Discussion

Prior to proceeding to the main Discussion section of this chapter, a finding which was presented in section 3.3.4 mentioned above gave rise to the need for a further experiment. Results showed a significant difference between the EQ scores of the target participants in the Waiting and Story scenarios, with targets in the Story scenario having higher EQ scores on the whole as compared to targets in the Waiting scenario. This surprising finding opened up the possibility that the scenarios themselves impacted on the way in which targets subsequently answered the EQ questionnaire. Targets in the Waiting scenario were kept waiting for a short period of time while the researcher performed irrelevant tasks whereas in the Story scenario, the researcher narrated a series of mishaps experienced earlier that day. Considering the varying nature of these scenarios and their potential consequences on one's mental state, is it possible that the scenario experienced influenced the way in which the target responded to the subsequently presented EQ questionnaire? Specifically, did the Waiting scenario annoy or anger the participants such that they answered the questionnaire in an unempathising manner? Meanwhile, did the Story scenario engender empathic concern for the researcher, leading the targets who experienced this scenario to respond in an empathising manner on the EQ? While being tangential to the aims of this particular study, such findings, if replicated would imply that rather than being a measure of trait empathy, the EQ may be a measure of state empathy – responses being easily modified by our immediately preceding experiences. In order to examine the relationship between scenario and EQ scores further, Experiment 2 was carried out. The following section describes Experiment 2, which will be followed by the main Discussion of Experiment 1 and 2 (section 3.5).

EXPERIMENT 2

Did the Waiting and Story Scenarios Influence Targets' Responses on the Empathy Quotient (EQ)?

3.4.1 Rationale

As mentioned above, the aim of conducting this follow-up study was to investigate the impact of the Waiting and Story scenario on peoples' EQ scores. If scenarios have an impact on how the target fills in the EQ questionnaire, then individuals who experienced the Waiting scenario perhaps may have responded un-empathically as they may have felt annoyed, bored or irritable. On the other hand, those who experienced the Story scenario may have responded to the EQ in a compassionate manner as the scenario may have evoked an empathic mental state.

3.4.2 Methods

The method employed in this experiment is similar to that described in section 3.2.1 (Target Reaction Videoclips). The primary differences are that; (i) only the scenarios in question were enacted i.e. Waiting and Story; (ii) although a videocamera was placed in the room during the experiment, targets' reactions to the scenarios were not filmed (as the aim of this experiment was to investigate their EQ scores, rather than to develop stimuli). Ethical approval was obtained for this experiment from the Ethics Committee, School of Psychology, University of Nottingham.

3.4.3 Targets

Thirty undergraduate students (14 males and 16 females) aged between 18 and 23 (mean age= 20.1 years) from University of Nottingham Malaysia Campus and another local institution of higher education were randomly assigned to either the Waiting or Story conditions. Targets were of various nationalities: 21 Malaysians, 3 Sri Lankan, 2 British, 2 Korean, 1 Pakistani and 1 Zambian. Written informed consent was obtained from all participants.

3.4.4 Procedure

Targets were told that they would be filmed while posing specific facial expressions which would be used as video stimuli in a subsequent study. As a consequence a video camera was set in position (approximately 1.7 meters in front of the participant) in order to replicate proper filming procedure as was conducted in the Stimuli Development phase of Experiment 1. At the completion of either the Waiting or Story scenarios, targets were asked to look directly at the video camera and to form six facial expressions (*surprise, happy, fear, anger, sad, disgust).* The facial expression words were dictated by the researcher in the same order each time. The researcher pretended to switch on the videocamera prior to dictating the facial expression words. Once the targets had completed posing the six expressions, the researcher pretended to turned off the video camera. Targets then completed the EQ questionnaire. Prior to leaving the testing room, targets were debriefed about the true nature of the study and given the opportunity to ask any questions.

3.4.5 Results

Table 3.4 shows the EQ scores of targets in Experiment 2 for the Waiting and Story scenarios. The EQ scores of targets from Experiment 1 have been added alongside for reference.

	EQ scores	
	Waiting scenario	Story scenario
	Mean (*SD)*	Mean (*SD)*
Experiment 1 (*n*=20)	33.7 (12.94)	50.2 (5.49)
Experiment 2 (*n*=30)	44.27 (10.65)	43.87 (11.83)

Table 3.4: Targets' mean EQ scores in the Waiting and Story scenarios in Experiments 1 and 2.

An independent-samples *t*-test was conducted to compare target EQ scores for the Waiting and Story scenarios. There was no significant difference in EQ scores between the two scenarios, $t(28)=.1$, $p=.916$. This suggests that the scenario experienced did not influence the way in which targets in Experiment 2 responded to the EQ questionnaire.

3.4.6 Discussion

The findings of Experiment 1 with respect to how targets filled in the EQ questionnaire were not replicated in the current study suggesting that the scenario experienced does not impact on how targets self-reported their EQ. Therefore the difference in EQ scores obtained in Experiment 1 could be attributed to the coincidental allocation of individuals with inherently high or low empathy traits to the two scenarios. This conclusion is consistent with previous research wherein the EQ has been regarded as a measure with acceptable reliability and validity (Muncer & Ling, 2006) rendering it unlikely that the occurrence of a brief event would considerably alter an individual's reporting of their empathic traits.

3.5 General Discussion (Experiments 1 and 2)

Participants were able to deduce from relatively brief samples of behaviour which of four situations the targets had experienced. This implies that participants utilised successful strategies to retrodict the 'cause' of the specified response (Gallese & Goldman, 1998), despite considerable diversity in the manner in which targets reacted to each scenario. Thus, from observing just a few seconds of a person's reaction, it appears we can gauge what kind of event might have happened to that individual with considerable success. It is not clear from the current results exactly how long a sample of behaviour needs to be in order to allow successful identification, and this may be a question for future research. Nevertheless, this capacity constitutes a powerful tool for learning about events in the world, enabling us to benefit indirectly from the experiences of others.

Reactions to the Waiting scenario were identified more accurately in comparison to the other scenarios. This could be due to the nature of the behavioural responses themselves, as the responses in the Waiting scenario often included not only facial expressions but also gestures that could assist in identifying the scenario, such as yawning, sighing, or looking around. Responses to the other three scenarios were identified somewhat less successfully, presumably because the behaviours involved were more similar. For example, laughter was a fairly frequent response for all three scenarios. This is one shortcoming of a forced-choice procedure: success in selecting the correct answer is inevitably influenced by how similar it is to other incorrect options. The scenarios selected for this study elicited a range of reactions, but their degree of similarity was not easy to anticipate.

An alternative explanation for the better discrimination of reactions to the Waiting scenario is that the video of the researcher enacting this scenario was longer than for the other three scenarios, because of the nature of the event itself, which was a period of waiting. It is not immediately obvious that a longer event would necessarily be understood better than a shorter event, but this cannot be ruled out as a possibility. Nevertheless, the clips of the behavioural responses themselves did not systematically vary in length with the scenario experienced, so participants could not have used a low-level strategy such as the length of the clip they viewed to discriminate between reactions to the scenarios.

Eye movement analyses revealed that participants varied their strategy according to the scenarios the targets experienced. For all four of the scenarios, participants focused primarily on the targets' mouth with less time spent looking at the eyes. Nevertheless, for targets in the Waiting scenario participants spent slightly more time looking at the eyes and less time looking at the mouth than for targets in the other three scenarios, suggesting that the eyes were more informative for this scenario than the others. As discrimination was better for targets in the Waiting scenario and participants looked more at the eyes when viewing reactions to this scenario than at the others, one might be tempted to conclude that spending longer looking at the eyes does indeed result in better identification. However, the increased looking at the eyes may have been caused by features of the eye gaze behaviour of the targets in the videoclips. The targets subjected to the Waiting scenario were not in direct interaction with the researcher, and so were more inclined to look around the scene rather than at the researcher compared to targets in the other scenarios. Hence the eye movements of the targets in the videoclips may have attracted the attention of the participants viewing them, and made the scenario easier to recognise. Given that the relatively strong discrimination performance in the Waiting scenario and the increased looking to the eyes might have been the result of lower-level strategies such as these, the relationship between gaze behaviour and scenario discrimination was analysed separately for reactions to the Waiting scenario and the other three (Joke, Compliments, Story).

Surprisingly, looking at the eye region was associated with poorer identification for targets in three of the four scenarios and was unrelated with success for the fourth (Joke). These results suggest that the eyes are not the most informative facial region when determining what happened to the people in the videos. This result stands in contradiction to some studies which imply that typically developing individuals look more at the eyes than the mouth when viewing videos of other people (Klin et al., 2002) and the result appears to contradict previous studies which have claimed that the eyes are crucial for mental state understanding (Baron-Cohen et al., 1997). Instead, the results suggest that participants may find different parts of the face informative, depending on the specific situation. This is consistent with Cunningham, Kleiner, Bülthoff and Wallraven (2004) who reported that the mouth region is central in communicating information about certain mental states. More recently, Kirchner et al. (2011) reported increased fixation time in the mouth region as compared to the eye region in emotional recognition conditions (i.e. conditions high in social salience). It was interesting to find that individuals spent more time gazing at the eye and mouth regions for targets in the Joke and Compliments scenarios (as compared to the Waiting and Story scenarios) although the scenario discriminability for both the Joke and Compliments scenarios were the lowest. One would imagine that increased gaze time in the critical regions would increase accuracy of responses. On the other hand, it is possible that participants found the Joke and Compliments videoclips to be hard to discriminate hence required more information from the critical facial regions of targets, resulting in increased gaze time behaviours, although this may not have directly influenced the accuracy of their responses.

It was previously mentioned that there are a number of differences between the demands of the task reported here and other mentalising tasks that have been reported previously. It is argued that one of the strengths of this paradigm is that participants were never asked to identify the mental state of the targets in the videos. It is possible that, if participants were told to attempt to deduce the mental state, they might have gazed more at the eye region. Alternatively, the preference for the mouth could be a result of the dynamic nature of the videos. Blais, Roy, Fiset, Arguin and Gosselin (2012) propose that individuals' utilisation of the mouth region in emotion recognition may be related to a brain strategy that has developed to handle dynamic stimuli as the mouth region produces the most distinguishing motions across facial expressions. They explained that this strategy may have developed over time due to the dynamic nature of information conveyed from the mouth region and its relevance in an ecological context. Furthermore, although the targets in the videoclips were not interacting with the participants who viewed them, they were interacting with the researcher at the time of filming, who was sitting directly next to the camera. This effectively placed the participants who viewed the videos within the interaction, which represents a departure from previous methodologies (Klin et al., 2002).

One might expect that empathising scores from the EQ would correlate with mentalising performance in this task as people who are good at empathising may be better at getting a feel for what had happened to the targets in the videoclips. In their study examining the validity and reliability of the EQ questionnaire among adults; Lawrence et al. (2004) found a moderate positive correlation (r =.29, n=48, p=.03) between EQ scores and performance on the 'Reading the Eyes in the Mind' Task among adult participants. While the former study revealed only a modest relationship between EQ and the simple and un-naturalistic Eyes Task, the findings of the current study suggest that it does not stand up particularly well under more naturalistic circumstances. This may point to a relative weakness of the EQ questionnaire as it should relate to performance on a subtle and naturalistic mentalising task as used in this study. Additionally, individuals who have a good understanding of others' emotions and who spend more time looking at critical regions of the face for mental state information, *should* in essence perform better in the given mentalising task. Yet, this was found not to be the case, thus implying that increased gaze time at the eye or mouth regions and elevated EQ scores do not have a substantial impact on increased scenario reaction discriminability in the present mentalising task.

Before considering the broader implications of these findings, there is a limitation of the current experiment that should be noted. The use of flashcards as a cue to recalling the various scenarios resulted in an inability to record response times for the task. Although participants were not instructed to respond quickly and were given as much time as they needed to make an accurate decision, response times could potentially have given additional information about how difficult participants found the task. A further problem with using flashcards is the possibility that some bias could have arisen from the researcher's involvement in the procedure. However, the order of presentation of the cards was carefully counterbalanced to ensure that cues to the correct response were not provided. Nevertheless, to overcome this issue, flashcards were not used in the remaining experiments in this thesis.

Is it possible that participants could infer what happened to the person in the video without mentalising at all? An argument could be advanced that participants 'match' behaviour to situation according to a system of behavioural rules (Perner & Ruffman, 2005). For example, is it possible that participants associated a smiling face with the Joke scenario? This seems implausible, given the wide range of behavioural responses produced by the people in reaction to the various scenarios: in most cases, there is no simple matching between the scenario and the facial expression.

It has recently been argued that people may perform some mentalising tasks such as recognising emotions through activation of representations that have bodily formats (mirror neurons being a main candidate for this), without generating any higher-level propositional representations of mental states. Goldman and Vignemont (2009) and

Goldman (2012) refer to this as 'low-level mentalising', but argue that other non-embodied processes might be involved at later stages of emotion recognition, such as at the stage of attributing the emotion itself. Similarly, Gallese (2005) acknowledges that emotions can be understood via either an embodied process, or a more explicit propositional route through "cognitive elaboration of their visual properties". In this task where there was no requirement to identify the mental states of the targets in the videoclips at all, a stronger case might be made for the more direct route from observing the behaviour to understanding the situation.

Research with infants has demonstrated that by the age of one, babies may be able to understand intentional goal-directed actions (Gergely, Nádasdy, Csibra, & Bíró, 1995) and appear to show sensitivity to the belief state of other individuals before two years of age (Onishi & Baillargeon, 2005). While it is surely the case that these abilities are supplemented by more sophisticated and explicit propositional representations of mental states with age, it seems unlikely that these low-level mindreading processes become obsolete. It is plausible to suggest that these processes might be engaged in this mentalising task due to its emphasis on making sense of behaviour rather than naming a mental state. Given the changing views on the nature of mentalising processes, it seems ever more important to channel efforts into devising tasks such as the one reported here that closely approximate how we understand other people's behaviour in real life situations.

In summary, from a brief sample of a few seconds of behaviour, adults are able to infer an event that happened to another individual. This appears to be evidence of a powerful retrodictive mindreading process, which might allow us to benefit indirectly from the experiences of others. Looking at the eyes was not a successful strategy for deducing what had happened to the individual in question, and participants tended to vary their viewing strategy according to what the individual in the video had actually experienced. This suggests that participants are affected by the cues present in the person's behaviour to attend to the parts that will be most informative for making sense of it.

CHAPTER 4

Can Individuals With ASD Guess What Happened To Others From Their Brief Behavioural Responses?

EXPERIMENT 3

4.1 Introduction

Impairments in social communication are one of the key diagnostic features of autism spectrum disorders (ASD; Schultz, 2005). One theory proposes that individuals with ASD are impaired in developing a 'theory of mind,' along with the associated mentalising skills (Baron-Cohen, Leslie, & Frith 1985), a capacity that enables us to impute mental states to others. Being able to identify mental states is an important cognitive process that equips us to understand a person's behaviour. Mentalising thus allows us to make predictions about the future behaviour of an individual based on our knowledge of relevant aspects of the situation. Conversely, the same skills allow us to reason backwards from observed behaviour to an antecedent cause, a process sometimes referred to as retrodiction (Gallese & Goldman, 1998).

The majority of research conducted with both ASD and neurotypical populations has focused on behavioural prediction as a particular kind of mentalising. For example, in its typical form the classic false belief task involves predicting where an individual will look for an item based on his/her knowledge of the situation at hand (Baron-Cohen et al., 1985), and numerous other tasks conceived subsequently have also involved behavioural prediction (Hirschfeld, Bartmess, White, & Frith, 2007; LeBlanc et al., 2003; Perner, Frith, Leslie, & Leekam, 1989; Senju, Southgate, White, & Frith, 2009). This is perhaps surprising given that another function of mentalising, retrodiction, is arguably more prevalent in everyday experience. In daily lives we frequently observe people reacting or behaving in a particular manner, leading us to try to determine what provoked that reaction. If we are successful, then effectively we come to know an aspect of the world through the lens of another mind, where the mind in question is embodied in a behavioural reaction. Little is known about these retrodictive mentalising processes in people with ASD. In so far as mentalistic prediction is impaired in ASD, one might extrapolate to suppose that retrodiction is impaired also, but it does not necessarily follow. Hence, the current study will investigate the scope of mentalising impairments in ASD – do such impairments extend to retrodiction or is the process of retrodiction intact in ASD?

On the other hand, considerable research has been conducted in which individuals with ASD were presented with samples of behaviour (usually facial expressions) and asked to identify the mental state of the individual, without requiring any inference about the situation that might have caused the mental state in question. Baron-Cohen, Jolliffe, Mortimore, and Robertson (1997) devised a task they called "Reading the Mind in the Eyes" and reported that individuals with ASD were impaired in identifying complex mental states from images of the eye region of the face. They argued, contrary to previous claims (Premack & Woodruff, 1978), that mental states are often directly observable from people's behaviour, especially from facial expressions. In making this case, Baron-Cohen et al. (1997) distinguished between high-level and low-level mentalising skills (see also Goldman & Vignemont, 2009; Tager-Flusberg, 2001). High-level mentalising involves reasoning about mental states based on prior knowledge of their relationships with one another and with specific situations; low-level mentalising involves inferring mental states from indicators such as behavioural cues, especially facial expressions.

Baron-Cohen et al. (1997) postulated that the eye region is crucial for identifying mental states in facial expressions (see also Smith, Cottrell, Gosselin, & Schyns, 2005) but that people with ASD are uniquely less able to use information from the eyes to infer such mental states. This appears to be consistent with research which has found that individuals with ASD have a lesser tendency to look at the eye region than neurotypical individuals (Hernandez et al., 2009; Klin, Jones, Schultz, Volkmar, & Cohen, 2002). The argument can be made that early differences in attention to social stimuli, especially to the eye region of the face, lead to difficulties acquiring social information, resulting in a myriad of social abnormalities including difficulties in interpreting facial expressions along with more general mentalising difficulties (Corden, Chilvers, & Skuse, 2008).

This viewpoint encounters some anomalous data. Firstly, a number of studies have either failed to report reduced looking at the eyes in those with ASD (Bar-Haim, Shulman, Lamy, & Reuveni, 2006; Freeth, Chapman, Ropar, & Mitchell, 2010; Freeth, Ropar, Chapman, & Mitchell, 2010; Freeth, Ropar, Mitchell, Chapman, & Loher, 2011; Rutherford & Towns, 2008; Van Der Geest, Kemner, Verbaten, & Van Engeland, 2002; Wagner, Hirsch, Vogel-Farley, Redcay, & Nelson, 2013) or failed to support the claim that those with ASD are impaired specifically in interpreting information from the eyes (e.g. Back, Ropar, & Mitchell, 2007; Song, Kawabe, Hakoda, & Du, 2012). Secondly, a relationship between looking at the eye region and actual task performance has not always been found experimentally. For example, Corden, Chilvers and Skuse (2008) found that the time spent looking at the eye region of faces correlated with success in identifying fearful faces, but no other facial expressions. Moreover, Boraston et al. (2007) found no relationship between expression identification and time spent looking at the eye region. Third, while some studies have found a relationship between severity of social symptoms of autism as measured by the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000) and mentalising task performance including performance in looking at the eyes (e.g. Klin et al., 2002), others have not (e.g. Corden et al., 2008; Joseph & Tager-Flusberg, 2004) questioning the causal relationship between mentalising deficits and the social difficulties in ASD.

One reason for inconsistencies in the literature may be the range of different paradigms that have been used. Perhaps group differences are most likely to be found in studies with naturalistic stimuli which closely approximate the complexities of everyday social interaction where facial expressions are dynamic, brief and subtle. The majority of previous studies used posed static images of exaggerated emotional expressions, frequently presented for several seconds (Kennedy & Adolphs, 2012; Tanaka, Kaiser, Butler, & Le Grand, 2012). Moreover, even those using dynamic stimuli have typically included expressions posed by actors making it unclear what the "correct" answer should be. Usually, the answer is agreed upon by consensus, yet this may not reflect the actual mental state of the actor.

A notable exception to this was a study conducted by Boraston, Corden, Miles, Skuse and Blakemore (2008) who presented pictures or sounds of highly positive valence (such as a photo of kittens or a baby’s laugh) and filmed participants’ resulting spontaneous expressions. Later, participants with or without ASD were required to distinguish between these real "happy" expressions and other “happy” expressions posed by the same individuals. While both groups of participants could distinguish between real and posed expressions to some degree, participants with ASD were impaired. Moreover, those with ASD spent less time looking at the eyes than the comparison participants, suggesting the eyes may be crucial for interpreting naturalistic expressions, particularly genuine smiles. While the findings suggest that people with ASD are less able to see the difference between the two types of smile (genuine and posed), they do not tell us whether people with ASD are impaired in differentiating between different types of naturalistic expression.

In light of the comments made above, a retrodictive mindreading task was developed to provide a measure of mentalising that requires participants to interpret naturalistic stimuli (see Chapter 3, Experiment 1). Participants were shown people’s (targets’) spontaneous reactions to four scenarios filmed during an interaction with the researcher; participants were then asked to determine which of the four scenarios the target had experienced. A key strength of this task is that there is a definite correct answer against which the participant's response can be compared. In other words, the researcher knows independently of the target's reaction which scenario the target experienced. The participant, in contrast, can only base his or her judgment on the target's reaction. In some ways, this might be seen as preferable to a task in which the participant is asked to estimate the target's emotion, for there is no certain way of determining the target's true state of emotion other than by interpreting his or her reaction.

It was shown in Experiment 1 that neurotypical individuals could infer previous events from brief samples of behaviour with considerable success. Eye movements were also recorded and it was discovered surprisingly that most time was spent looking at the mouth not the eyes, and moreover that good performance in identifying the scenario was associated with looking less at the eyes and more at the mouth. These findings supported the view that looking at the eye region is not always conducive to good performance when interpreting facial expressions.

This study used the same task as in Experiment 1 to investigate retrodictive mindreading in groups of individuals with and without ASD. It was predicted that a) people with ASD would have difficulty determining the scenario that the target had experienced, b) consistent with the previous study, it was hypothesised that neurotypical participants would look more at the mouth than the eyes.

4.2 Methods

The study was divided into two parts; Stimulus Development and Main Experiment. Ethical approval was obtained from the Ethics Committee, School of Psychology, University of Nottingham.

4.2.1 Main Experiment

The stimuli used in this study were exactly the same as used in Experiment 1. For a comprehensive description of how the stimuli were developed, please refer to Chapter 3 section 3.2.1.

Participants

Thirty male participants took part in the study. Written informed consent was obtained from all. Neurotypical participants (*n*=15) were recruited from the University of Nottingham United Kingdom while participants with an ASD (*n*=15) were recruited from across the United Kingdom through their respective schools or centres associated with the National Autistic Society. The experiment was conducted at the University of Nottingham for neurotypical participants and at their respective schools and centres for participants with ASD. Participants with ASD had been formally assessed by mental health professionals in line with DSM-IV criteria (American Psychiatric Association, 2000) and subsequently received a Statement of Special Education Needs for autism or ASD. The Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000) was conducted on the participants with ASD to independently confirm their diagnosis. Communication (*M*= 3.3), reciprocal social interaction (*M*= 7.3), and total ADOS (*M*= 10.67) scores were obtained. Three of the fifteen participants did not meet the cut-off for ASD on the ADOS, but were included in the study as all had a previously established diagnosis of ASD or autism by trained mental health practitioners. Nevertheless, all analyses were repeated with the three participants who did not meet the cut-off for ASD removed from the data set and the pattern of results was identical to those reported in the following sections. All participants also completed the Wechsler Adult Intelligence Scale-III (WAIS-III; Wechsler, 1997) which provided measures of verbal IQ, performance IQ and full scale IQ. All participants completed the Autism Spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001, see Appendix B) which measures levels of autistic traits in adults. An independent-samples *t*-test showed that the ASD group scored significantly higher on the AQ than the comparison group $t(28) = 4.45$, $p < .001$. No significant differences were found in age or any IQ measures between the groups (all *ps* >.291). See Table 4.1 for summary details.

	ASD Mean (*SD*)	Neurotypical Mean (*SD*)
N	15	15
Age	20.6 (5.6)	18.7 (3.7)
Verbal IQ	100.5 (21.7)	105.5 (18.0)
Performance IQ	95.5 (18.7)	101.1 (16.6)
Full Scale IQ	98.5 (21.1)	104.2 (18.3)
AQ	25.7 (7.0)*	16.7 (3.5)*

Table 4.1: Participant characteristics.
** Significant difference between groups, p < .001*

This study involved individuals with ASD. In testing individuals with ASD, the challenge lies in determining a suitable comparison group and most importantly, what measures will be used in matching participants. Some of the commonly used measures to compare groups include chronological age, mental age, gender, verbal IQ and performance IQ. Thus the selection of appropriate comparison groups plays a large role in ensuring that the differences in performance in a given experimental task are not due to trivial differences in intellectual functioning, verbal ability age or other related factors. In this study, participants with ASD were matched on a group basis with typically developing comparison participants with no reported neurodevelopmental diagnoses. They were matched based the following criteria; chronological age, gender, verbal IQ, performance IQ and full scale IQ. Individuals with a range of cognitive abilities were recruited; participants with ASD obtained full scale IQ scores between 70 to 132 while the typically developing comparison group had IQ scores of 77 to 139. A participant pool with a wide range of abilities was selected in order to avoid the possibility of only selecting individuals with a particular intellectual ability level (i.e. high or low) and run the risk of the results of the study not being generalisable to all individuals with ASD as only a minority of the population was studied. Nevertheless, all participants had an IQ of over 70 which places them within the 'normal range' of intelligence, deemed to be high-functioning i.e. none of the participants could be regarded as having learning disabilities. This high functioning population was selected primarily to be able to deal with the verbal demands of the task and to allow comparison with a typically developing group. In addition all participants in this experiment were males, this resulted in a more homogeneous sample and the majority of individuals with ASD are male. Correlation analyses were conducted to determine if there were any relationships between participants' age and intellectual ability and performance on the given mentalising task.

Materials and Apparatus

The four scenarios videoclips enacted by the researcher were used in this study. The main stimuli were the 40 edited videoclips showing targets' reactions from the Stimulus Development phase of Experiment 1 (also used in Experiment 1). Each videoclip was interspersed with a rectangular image of the four scenario names (i.e. *Joke, Waiting, Story, Compliments*) in black font on white background. The rectangular shaped image was divided equally into four parts for each scenario name. Consistent with the coloured borders in the scenario videoclips, the perimeters enclosing each scenario name in the image had the same corresponding coloured borders. This was done in order to assist memory recall of the scenario videoclips as enacted by the researcher. The 40 videoclips showing the targets' reactions did not have coloured borders. All videoclips (i.e. scenario clips enacted by researcher and target reaction clips from the Stimulus Development phase) were shown on a

17 inch TFT monitor which was incorporated into the Tobii T60 Eye Tracker (data rate 60 Hz) and presented using Tobii Studio software.

The AQ (Baron-Cohen et al., 2001) consists of 50 questions with a four-option forced choice response format (*strongly agree, slightly agree, slightly disagree, strongly disagree)*. Participants were given as much time as they required to complete the questionnaire.

Design

A mixed design was used, where all participants in each group viewed the four scenario videoclips as enacted by the researcher followed by the 40 target reaction videoclips.

Procedure

At the start of the experiment, participants were shown the scenario videoclips enacted by the researcher in a counterbalanced order. The purpose of presenting the scenario videoclips was to provide the participants with vivid information on what the targets experienced. Participants sat approximately 60 centimetres from the Tobii T60 screen, subtending a visual angle of 28 degrees horizontally and vertically. A 9-point eye-tracking calibration procedure was then conducted. Upon successful calibration, the 40 target reaction videoclips were presented in random order by the Tobii studio software. After each videoclip was shown, an image of the four scenario names appeared and the researcher asked, “Which of these scenarios had just occurred?” This image remained on the screen until participants gave an answer verbally to the previously presented videoclip, whereupon the researcher clicked the mouse to move on to the next videoclip. Participants’ verbal responses were recorded on a data sheet for all 40 videoclips. The participants then completed the AQ questionnaire.

4.3 Results

4.3.1 Could participants determine the scenario which happened to a target from their spontaneous reactions?

As with the previous study (i.e. Experiment 1), signal detection theory was used to analyse participant responses in order to investigate the key question: Are there significant group differences in the success in discriminating between the four scenarios according to the target's reaction? (refer to section 3.3.1 for description of signal detection method).

The neurotypical participants were able to correctly discriminate differences between target reactions across scenarios as *d'* scores were significantly greater than 0 for all four scenarios [Joke $t(14)=12.07$, $p<.001$; Waiting $t(14)=25.08$, $p<.001$; Story $t(14)=9.18$, $p<.001$; Compliments $t(14)=11.32$, $p<.001$]. Participants with ASD also successfully discriminated between target reactions across all four scenarios: Joke $t(14)=8.39$, $p<.001$; Waiting $t(14)=11.9$, $p<.001$; Story $t(14)=5.92$, $p<.001$; and Compliments $t(14)=3.38$, $p=.004$. See Figure 4.1 for participant mean *d'* scores and Table 4.2 for participant mean accuracy and false alarm rates.

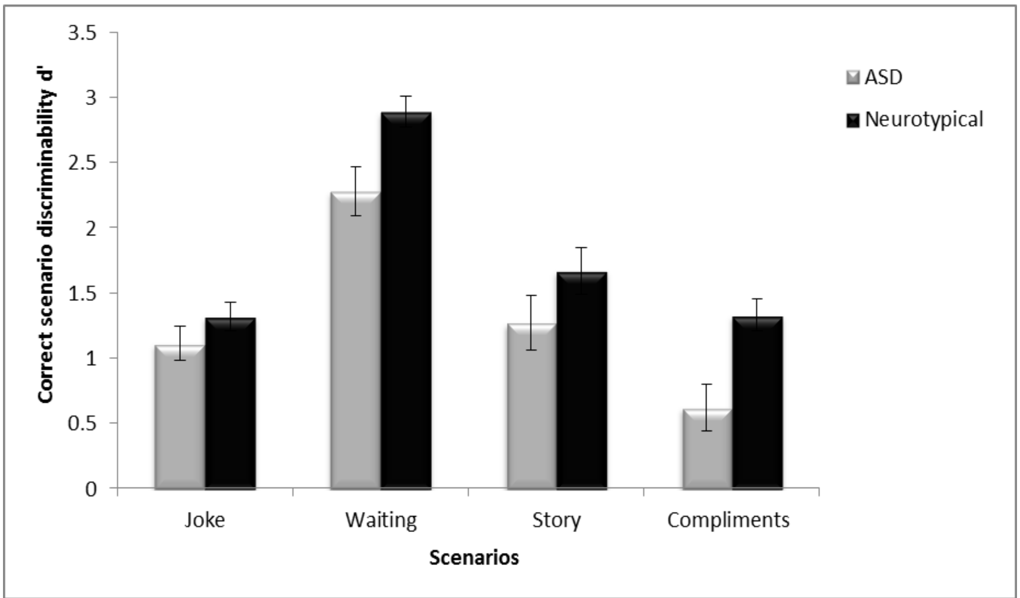

Figure 4.1: Correct scenario discriminability based on target reactions (mean d' score).
(Error bars represent standard errors of the mean)

	ASD		Neurotypical	
	Accuracy	False alarm	Accuracy	False alarm
Joke	6.07 (60.7%)	6.13 (20.4%)	5.47 (54.7%)	3.13 (10.4%)
Waiting	8.60 (86.0%)	3.63 (12.1%)	9.87 (98.7%)	3.00 (10.0%)
Story	5.07 (50.7%)	3.33 (11.1%)	6.67 (66.7%)	2.93 (9.8%)
Compliments	3.20 (32%)	3.67 (12.2%)	5.47 (54.7%)	3.27 (10.9%)

Table 4.2: Participant mean accuracy rates and false alarm rates.
Accuracy : Number correct out of 10 (% in brackets)
False alarm: False alarms out of a possible 30 (% in brackets)

A 2x4 (group x scenario) ANOVA was performed in order to examine whether the groups (between participants factor) differed in how well they could discriminate between scenarios (within participants factor) based on their interpretation of the targets' reactions. A main effect of scenario was found, $F(3,84)=59.28$, $p<.001$. Posthoc *t*-tests with Bonferroni correction revealed that participants were better at discriminating when targets were reacting to the Waiting scenario than the other three scenarios (all *ps*<.001). Additionally, reactions to the Story scenario was easier to identify than the Compliments scenario ($p<.001$). There was also a main effect of group, $F(1, 28)= 8.95$, $p<.001$, indicating that ASD participants were significantly poorer at discriminating between scenarios according to target reactions as compared to their neurotypical counterparts. The interaction between scenario and group was not significant ($p=.230$).

Chi-square analyses were then employed to examine participants' pattern of error responses. Four separate chi-square analyses were performed for each scenario in both the neurotypical and ASD groups. Table 4.3 shows frequencies of neurotypical participants' error responses. Findings showed that neurotypical participants' errors were not equally distributed for the Joke scenario [X^2(3, n= 69) = 18.09, *p* <.001], which they primarily mistook for reactions to the Compliments scenario. Their errors were also not equally distributed for reactions to the Story scenario [X^2(3, n= 49) = 10.45, *p* =.005] which they tended to mistake for reactions to the Waiting scenario. For reactions to the Compliments scenario participants' errors were also not equally distributed [X^2(3, n= 64) = 13.72, *p* <.001], mainly confusing them with reactions to the Joke scenario. However their errors for the Waiting scenario were equally distributed across the three remaining response options [X^2(3, n= 2) = .17, *p* =.60].

	Joke	Waiting (observed error responses)	Compliments	Story	Expected error responses
Joke	-	7	35	27	23
Waiting	0	-	1	1	.67
Compliments	35	12	-	17	21.33
Story	11	27	11	-	16.33

Table 4.3: Neurotypical participants' error response distribution (in frequencies).

Table 4.4 shows frequencies of ASD participants' error responses. The error responses of participants with ASD were not equally distributed for reactions to the Joke scenario [X^2(3, n= 55) = 6.25, *p* =.04] whereby they mainly mistook them for reactions to the Compliments scenario. Their errors were also not equally distributed for reactions to the Waiting scenario [X^2(3, n= 21) = 14, *p* <.001], with participants mainly mistaking them for reactions to the Story scenario. Furthermore, participants' errors were not equally distributed for reactions to the Compliments scenario [X^2(3, n= 99) = 65.88, *p* <.001], which they mainly mistook for reactions to the Joke scenario. Their error responses to the Story scenario were equally distributed across the three remaining response options [$X^2(3, n= 68) = 3.03, p =.22$].

	Joke	Waiting (observed error responses)	Compliments	Story	Expected error responses
Joke	-	13	27	15	18.33
Waiting	7	-	0	14	7
Compliments	71	12	-	16	33
Story	16	27	25	-	22.67

Table 4.4: ASD participants' error response distribution (in frequencies).

As discriminability scores were much higher for reactions to the Waiting scenario compared with the other three scenarios, in further analyses data associated with the Waiting scenario were considered separately, as in Experiment 1. Overall success in discriminating between target reactions across the scenarios was positively related with full scale IQ, *r*=.38, *n*=30, *p*=.042. Similarly, the relationship between full scale IQ and discrimination of the targets' reaction in the Waiting scenario approached significance (*r*=.33, *n*=30, *p*=.074). When considering each group separately, overall scenario discrimination (excluding the Waiting scenario) was positively related with full scale IQ in the ASD group (*r*=.54, *n*=15, *p*=.043). There was also a positive relationship between accuracy in detecting reactions to the Compliments scenario and full scale IQ scores in the ASD group (*r*=.63, *n*=15, *p*=.011). The same relationship approached significance for reactions to the Waiting scenario (*r*=.47, *n*=15, *p*=.083) and non-significant positive correlations were observed for responses to the other two scenarios. In the neurotypical group, all correlations between IQ and ability to discriminate the scenario based on targets' reactions were close to 0 apart from the Joke scenario where a negative relationship approached significance (*r*=-.47, *n*=15, *p*=.084), suggesting that the reported positive correlations for full-scale IQ in the overall participant sample may be explained by the ASD group. Finally, as some significant correlations with IQ were observed for the ASD group, the ANOVA comparing the two groups for ability to discriminate scenarios based on targets' reactions was repeated with IQ entered as a covariate. This ANCOVA revealed the same pattern of main effects of scenario, $F(3,81)=4.12$, $p=.009$ and group, $F(1,27)=7.96$, $p=.009$, suggesting that any group differences in the ability to discriminate target reactions across the scenarios cannot be explained by the way IQ affected performance.

4.3.2 What were participants' eye gaze patterns?

The objectives of conducting eye-tracking analyses were to ascertain: (a) whether participants preferred to look at the mouth more than the eyes of the targets, (b) whether those with ASD had different looking preferences than neurotypical participants, and (c) whether participants' ability to discriminate the scenarios according to target reactions was related with looking at certain regions of the target's face (eye or mouth). The dynamic areas of interest (AOIs) function in Tobii Studio 3.0 was utilised to analyse and code the eye-tracking data (identical to Experiment 1). This enables the specification of AOIs which move and change form with the movements of the target. AOIs were outlined on the eye and mouth regions of the video stimuli to determine the eye movement metrics. The Total Fixation Duration (seconds) metric was used to calculate the total duration for all fixations within the AOIs separately. Fixation is defined by the standard Tobii fixation filter as two or more consecutive samples falling within a 35 pixel radius.

Figure 4.2 shows the mean percentage of total gaze time for the eye and mouth of the target when reacting to each of the four scenarios. As the duration of the videoclips differed and the participants varied in their total time looking at the videos, the percentage of gaze time spent looking at the eye and mouth regions of targets for each videoclip was calculated (i.e. time spent looking at eye/mouth region ÷ total gaze time * 100). The data were normalized by a square root transformation but untransformed means appear in the figure for ease of understanding.

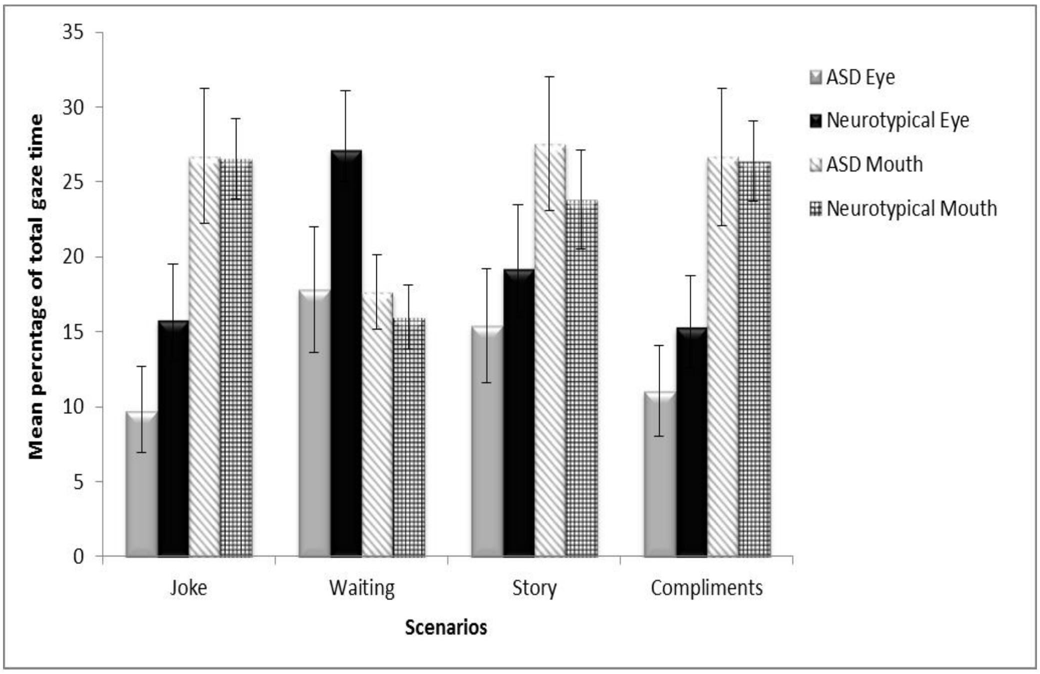

Figure 4.2: Mean percentage of total gaze time at the eye and mouth of targets across four scenarios.
(Error bars represent standard errors of the mean)

A 2x2x4 mixed ANOVA was performed on gaze time, with group (ASD or neurotypical) as a between-participants factor and scenario experienced by the target (Joke, Waiting, Story, Compliments) and region of the face (eyes or mouth) as within-participants factors. No main effects for scenario experienced by the target (p=.101) and group (p=.264) were found but there was a main effect for face region, $F(1,28)= 6.86$, p=.013, indicating that participants spent more time looking at the targets' mouth as compared with the targets' eyes. Furthermore, a significant interaction between scenario and face region was found, $F(3, 84)= 27.6$, $p<.001$. In order to interpret this interaction, separate one-way ANOVAs were performed to examine the effect of the scenario experienced by the target on gaze time for the target eye and mouth regions separately. There was a significant effect of scenario the target experienced on the time the participant spent looking at the targets' eye region, $F(3,87)=21.21$, $p<.001$. Posthoc t-tests with Bonferroni correction showed that participants spent more time looking at the targets' eye region when the targets were reacting to the Waiting scenario compared with the other three scenarios (all *ps* <.001). Participants also spent more time looking at the targets' eye region when the targets were reacting to the Story scenario compared with the Joke scenario (p=.033). There was also a significant effect of scenario on time spent looking at the targets' mouth region, $F(3,87)$= 19.21 p<.001. Posthoc *t*-tests with Bonferroni correction revealed that participants spent more time looking at the targets' mouth when the targets were reacting to the Joke, Story and Compliments scenarios compared with the Waiting scenario (p<.001). The interaction was further investigated using paired sample *t*-tests, to assess the effect of face region (eye or mouth) for each scenario. Participants spent more time looking at the targets' mouth than eyes when the targets were reacting to the Compliments scenario, $t(29)$= -3.82, p< .001; the Joke scenario, $t(29)$=-4.15, p<.001; and the Story scenario $t(29)$= -2.57, p=.022. However, participants looked equally at both the eye and mouth regions when the targets were reacting to the Waiting scenario, $t(29)$=.84, p=.414. All other main effects and interactions were not significant. Notably, there was no interaction between time spent looking at the different facial regions and participant group, meaning that there was no evidence to suggest that the two participant groups (i.e. ASD and neurotypical) differed in their attentional priority for the targets' eyes and mouth.

4.3.3 Did the differences in eye gaze behaviour relate to participants' ability in distinguishing the scenarios targets reacted to?

It was found that the Waiting scenario was easier to identify compared to the remaining three scenarios. Additionally, participants' also displayed dissimilar eye gaze behaviours in the Waiting compared to the other three scenarios. Hence, reactions to the Waiting scenario was analysed separately from reactions to the Joke, Story and Compliments scenarios when investigating the relationship between eye gaze patterns and scenario identification. It was surprising to find that mean eye region gaze time did not correlate with accuracy of scenario identification (mean *d*' scores) across reactions to the three remaining scenarios (*r*=-.24, *n*=30, *p*=.201). Similar results were revealed for mean mouth region gaze time and success in detecting reactions to the scenarios (*r*=-.09, *n*=30, *p*=.641). The same relationships were also examined for responses to each scenario individually. Eye region gaze time did not correlate with *d'* for the responses to the Compliments (*r*=-.13, *n*=30, *p*=.515) and the Joke scenarios (*r*=.03, *n*=30, *p*=.893), but approached significance for reactions to the Story scenario (*r*=-.35, *n*=30, *p*=.057), indicating that participants who spent less time looking at the eye region were more accurate at discriminating reactions to the Story scenario. No significant relationships were found between mouth region gaze time and *d'* for responses to all three individual scenarios (all *p*s>.145). The Waiting scenario was analysed separately, revealing a similar pattern in which eye region gaze time (*r*=-.19, *n*=30, *p*=.320) and mouth region gaze time (*r*=-.29, *n*=35, *p*=.119) were not associated with correct scenario discriminability.

It is possible that the lack of relationships reported above were due to the inclusion of both groups (ASD and neurotypical) in the same analyses. Hence the analyses were repeated for each group in turn. No significant relationships were found between eye and/or mouth region gaze time and correct scenario identification within the ASD and neurotypical groups when analysed separately (all *ps*>.313). This suggests that individuals' abilities to discriminate between scenarios were not related to time spent looking at the critical face regions (eye or mouth), although it should be noted that the number of individuals in each group was small (n=15).

Nonetheless, other significant relationships associated with correct scenario discriminability were found. As with the analyses above, reactions to the Waiting scenario was examined separately. Overall success in detecting which scenario targets were reacting to was positively associated with full scale IQ scores across the three scenarios (*r*=.38, *n*=30, *p*=.042). Similarly, the relationship between full scale IQ scores and identification of reactions to the Waiting scenario approached significance (*r*= .33, *n*=30, *p*=.074). This suggests that participants with higher IQ performed better in the scenario reaction identification task. A positive relationship was also found between full scale IQ scores and accuracy in detecting reactions to the Compliments scenario (r=.47, n=30, p=.013).

In addition, participants' AQ scores were negatively correlated with the overall *d'* mean (excluding the Waiting scenario), r=-.55, n=30, p=.002, indicating that individuals who reported more autistic traits were less successful at discriminating the scenarios from one another. Furthermore, a negative relationship was found between participants' AQ scores and correct scenario discriminability across each scenario independently, Compliments (r=-.42, n=30, p=.022); Joke (r=-.42, n=30, p=.024); Story (r=-.40, n=30, p=.032); and Waiting (r=-.53, n=30, p=.014).

To address the possibility that these results were driven by the inclusion of the two participant groups in the analysis, the same analyses were conducted for each group in turn. Similar to the findings reported above, overall scenario reaction identification success (excluding Waiting scenario) was positively associated with full scale IQ scores in the ASD group (r=.54, n=15, p=.034). A positive relationship was also found between correct identification of reactions to the Compliments scenario and full scale IQ scores in the ASD group (r=.63, n=15, p=.013). Nevertheless, this relationship was not found for reactions to the other three scenarios (all ps>.05). Interestingly, accuracy in identifying reactions to the Compliments scenario was negatively associated with ADOS scores, (r=-.52, n=15, p=.045); and yet again not replicated in the Joke, Waiting and Story scenarios (all ps>.413). These findings suggest that ASD participants with higher IQs were more successful at detecting reactions to the Compliments scenario, whereas ASD participants with higher ADOS ratings were less successful at detecting reactions to the Compliments scenario. Nonetheless, it was surprising to find that scores of both the communication and reciprocal social interaction subscales on the ADOS were not associated with scenario reaction identification (all ps>.172). None of these relationships were found in the neurotypical group (all *ps*>.484), suggesting that reported correlations for full scale IQ score in the overall participant sample may be explained by the ASD group.

4.3.4 Did the EQ scores of targets affect participants' ability to deduce what had happened to them?

As in Experiment 1, analyses were conducted to investigate whether the EQ scores of targets (i.e. people in the reaction videoclips) had an impact on participants' ability to correctly identify the scenarios they reacted to. Targets who rated themselves as having higher empathic abilities may in fact be more expressive; hence it was hypothesised that this may be a component factor that could influence participants' ability in successfully identifying the scenarios. Table 4.5 shows the targets' mean EQ scores and participant accuracy rates broken down by scenario. The accuracy rates describe the percentage of participants who successfully identified the scenario from the target reaction videoclips ([number of participants who correctly identified the scenario in the videoclip ÷ 15] * 100). There were a total of 40 videoclips (i.e. 10 videoclips for reactions to each of the 4 scenarios) with 19 males and 21 females being filmed in the videos.

	Target EQ Scores Mean (*SD*)	ASD Mean accuracy in percentage (*SD*)	Neurotypical Mean accuracy in percentage (*SD*)
Joke	38.7 (10.22)	62.0 (22.89)	51.33 (29.15)
Waiting	33.7 (12.94)	81.67 (19.7)	98.67 (2.81)
Story	50.2 (5.49)	55.33 (19.39)	70.0 (25.19)
Compliments	42.9 (9.52)	41.33 (15.0)	56.0 (28.84)

Table 4.5: Targets' mean EQ scores and participants' accuracy rates.

The relationship between the EQ scores of the targets and participants' abilities in correctly detecting the scenario reacted to was investigated separately for each scenario using Pearson product-moment correlation coefficient with Bonferroni adjusted alpha level of .0125. No significant relationship was found between target EQ scores and the ability of neurotypical participants to correctly identify reactions to all scenarios (Joke: r=.50, n=10, p=.158; Waiting: r=.13, n=10, p=.725; Story: r= -.10, n=10, p=.783; and Compliments: r=.29, n=10, p=.425). Similarly for participants with ASD, no significant relationships were revealed between target EQ scores and participant accuracy rates for reactions to all scenarios (Joke: r=.44, n=10, p=.212; Waiting: r=-.15, n=10, p=.683; Story: r=-.27, n=10, p=.449; and Compliments: r .20, n=10, p=.578).

4.4 Discussion

Consistent with previous findings (i.e. Experiment 1) in spite of differences in the level of success across scenarios, participants were generally able to distinguish the event which took place merely by viewing several seconds of a target's behavioural reaction. This suggests that both neurotypical and ASD participants employed effective strategies to determine the cause of the presented behavioural responses, and this qualifies as something that Gallese and Goldman (1998) call *retrodiction*. Effectively, participants could access something that happened in the world that they did not sense directly, through the window of another person's mind – assuming that the other person's mind is embodied in their behaviour.

The findings in this study followed the same pattern as found in Experiment 1, with the Waiting scenario being identified more easily than the other three scenarios. This is likely to be because the actual responses of the targets in the videos were more distinctive in the Waiting scenario than in the other three scenarios. Because a forced choice format was used, the success of identifying one scenario was partly a function of being able to rule out other scenarios. While scenarios were selected which would give rise to a range of expressive reactions, it was difficult to predict exactly how the targets would respond. In real life, different people respond in many ways to the same event. It is an impressive feat of human mentalising that we are able to estimate fairly accurately what caused a target's reaction from a limited range of possible causes, despite the fact that the target's reactions can be varied. Because the stimuli used were spontaneous rather than standardised target reactions, the current study effectively embraces this human capacity to connect a range of behavioural responses with a specific causal antecedent.

The current study aimed to determine whether individuals with ASD would be less successful in interpreting target reactions and this proved to be the case. This finding is consistent with the suggestion that group differences in mentalising can be found in naturalistic tasks which reflect some of the demands of everyday social situations, where facial expressions are brief and subtle. The finding in this study is perhaps comparable with the report that individuals with ASD have difficulties in tasks that require them to infer complex emotions (e.g. Golan, Baron-Cohen, Hill, & Golan, 2006). Similarly, Sawyer, Williamson, and Young (2012) found that individuals with Asperger's Syndrome were less accurate than neurotypical adults in recognising complex mental state expressions.

It could be argued that in order to successfully identify the scenario in the mentalising task, one would only need to 'match' the responses using behavioural rules, while completely bypassing an inference of mental state that underlies the behavioural reaction ("Povinelli's challenge", Povinelli & Vonk, 2003). Nevertheless this is unlikely to be the case given the variety of reactions to the same scenario made by the targets in the videoclips- surely no simple behavioural matching strategy could be used. Besides, Perner (2010) pointed out that even behavioural rules are not 'mind-blind behaviourism,' implying that being able to acquire and use such rules is tantamount to having a 'theory of mind' of a kind. Nonetheless, if this task does involve matching responses using behavioural rules, the impaired performance of those with ASD is still interesting insofar as it would suggest that people with ASD have difficulties in applying behavioural rules (or behavioural matching strategies) effectively.

Participants spent longer looking at the mouth than the eye region for targets' reactions to all the scenarios apart from the Waiting scenario, for which participants spent a similar amount of time looking at the eyes and mouth. These findings are consistent with Experiment 1 where it was found that more time was spent looking at the mouth than the eye region for reactions to all four scenarios with this effect reduced (although not absent) for the Waiting scenario. Most importantly for the aims of the current study, there were no differences between the groups with and without ASD in the time spent looking at the eyes. This suggests that the impairment in interpreting the targets’ reactions in those with ASD is not explained by failure to use information from the eye region of the targets’ face. Instead it is concluded that both people with and without ASD approach this task by looking at the parts of the face that are most diagnostic for inferring which scenario caused the targets’ reaction, but that people with ASD for some as yet undetermined reason appear to be poorer at making the correct inference.

Much previous research has emphasised the importance of using information from the eye region of the face to recognise facial expressions (e.g. Baron-Cohen et al., 1997; Smith et al., 2005). Moreover, studies have suggested that impairments in mentalising in ASD may partly be explained by a tendency not to use information from the eye region of the face (e.g. Corden et al., 2008; Spezio, Adolphs, Hurley, & Piven, 2007). While the findings of this study may seem surprising in light of this, they are consistent with a growing body of research which suggests that the mouth may be more important than previously recognised. For example, Blais, Roy, Fiset, Arguin, and Gosselin (2012) conducted ideal observer analyses and found that the mouth region contains the most useful information for recognition of dynamic facial expressions. They speculate that this may be because the movements of the mouth are most useful for recognising natural facial expressions. Furthermore, it has frequently proved difficult to find a relationship between facial viewing strategy and task performance (e.g. Sawyer et al., 2012) and this highlights a possible dissociation between where a person is looking and the information that is actually processed (Arizpe, Kravitz, Yovel, & Baker, 2012).

Participants' ability as indexed by full scale IQ was related with success in discriminating between the scenarios based on the targets' reaction, although this could not explain the group differences in interpreting the reaction of the target. Further analyses revealed that these relationships between IQ and task performance only held for those diagnosed with ASD. This suggests that in neurotypical individuals, the ability to discriminate the scenario to which a target is reacting is relatively independent of a person's IQ level. However, for the participants with ASD, the relationship could suggest that those who are higher functioning have worked out strategies for identifying the scenario to which the targets responded, strategies that might be different from those used by comparison participants. Similar to the findings in Experiment 1, no relationships were found between target EQ scores and participants' accuracy in identifying scenarios the targets experienced. This suggests that the self-reported empathic abilities of targets did not influence both neurotypical and ASD participants' performance in determining the preceding scenarios.

In summary, the findings suggest that, despite focusing on the same regions of the face, individuals with ASD had difficulties inferring what event caused an individual to behave in a particular way. The ability to make such inferences may be useful not only because it enables us to make sense of others' behaviour, but perhaps even enables us to benefit indirectly from the experiences of others. Through observing the reactions of others we may be able to learn something about events (both positive and negative) that we have not witnessed ourselves. Hence, participants effectively used the mind of the targets as a window to a view of the world that was beyond what they could apprehend with their ordinary senses. If individuals with ASD do not perform well in making such inferences, this could indicate not only that they have difficulty understanding other minds but also that they experience a barrier to aspects of the world that most of us can see through the lens of other minds.

CHAPTER 5

Can People Determine What Happened To Individuals With ASD From Their Brief Behavioural Responses?

EXPERIMENT 4

5.1 Introduction

As discussed in Chapter 4 (Experiment 3), individuals with ASD compared to neurotypical controls were shown to have significant difficulties in accurately distinguishing the scenarios that people experienced. One of the key differentiating factors of the approach used in this thesis was to not have participants infer and verbally label the mental states of the spontaneous responses of others. Rather, participants were asked to identify an objectively correct response i.e. the scenario which they believed was the antecedent to the presented spontaneous responses. Under these circumstances even, participants with ASD were found to struggle. It is plausible to suppose that one of the ways in which an individual comes to the correct scenario is by 'putting themselves in the other person's shoes', perhaps through a process of simulation. One explanation for the difficulties of those with ASD is that they were unable to perform such a mental simulation. Another explanation is that even though they can perform mental simulation, it is of no help in this task because they themselves would respond in a different or attenuated manner from the targets in the videoclips when faced with the same scenarios. If this were the case, then a process of simulation would be rendered considerably less effective for determining the scenarios to which the targets were responding. In consequence, this chapter asks the question- how would individuals with ASD respond to the four scenarios if they themselves were to experience them?

While the notion that individuals with ASD are incapable of feeling or expressing emotions (Kanner, 1971) is no longer prominent, the socioemotive and communication difficulties in ASD remain a hallmark and one of the most prominent features of the disorder. Indeed the difficulties associated with inferring and identifying mental states have been long researched in the population with ASD (as discussed in Chapter 2). Studies have shown that individuals with ASD have the ability to recognise basic mental states such as happiness, fear and anger (Loveland et al., 1997) but have difficulties with certain self-conscious mental states such as pride (Kasari, Sigman, Baumgartner, & Stipek, 1993) as well as shame and embarrassment (Heerey, Keltner, & Capps, 2003). Loveland et al. (1997) found that despite the ability to perform as well as typically developing individuals in emotion recognition tasks in laboratory settings, people with ASD often struggle in real-life situations. These difficulties are known to impact on their overall social functioning as they frequently have problems in everyday social-interactive spheres such as forming and maintaining friendships, sharing interests with others, and behaving appropriately at work, school as well as other social settings.

While much research has been conducted in the area of mental state recognition in people with ASD, there is a dearth of knowledge in regard to their ability for affective expression and response. Still, there have been a few studies which have endeavoured to illustrate the affective capabilities of individuals with ASD through the use of a variety of methods. Loveland et al. (1994) examined imitation and expression of facial affect in a group of 18 children with ASD and 24 children with Down syndrome (control group) matched for chronological age, mental age and cognitive ability. The participants were filmed and instructed to imitate five of the experimenter's facial expressions (imitation task) and to demonstrate five emotional states named by the experimenter (expression task). The five affective labels were happy, sad, angry, surprise and neutral. The findings showed that participants with ASD had equal difficulty in both tasks (imitation and expression) and they produced less recognisable expressions as compared to the individuals with Down syndrome in the expression task (where there was no model to imitate). Loveland et al. (1994) also reported that the responses of participants with ASD in both tasks encompassed odd behaviours and peculiar facial expressions, some of which looked 'rigid and mechanical'. Although this study tells us children with ASD may have difficulty producing expressions on request, it does not tell us whether there are differences in their expressivity when responding to actual events in real life.

One of the more commonly used ways of measuring affect expression is via direct observation of spontaneous facial expressions during social interactions. Snow, Hertzig and Shapiro (1987) investigated the expression of emotion in 10 preschool aged children with ASD along with 10 children who were developmentally delayed (both groups were matched for mental and chronological age). The children were individually filmed for 15 minutes in interactions with their mother, child psychiatrist as well as their kindergarten teacher. The findings revealed that while there were no differences in the occurrence of negative affect between groups, children with ASD exhibited less positive affect compared to their developmentally delayed counterparts. In addition, while the positive affect displayed by the control group was more likely to be linked to partner-interactions, the positive affect demonstrated by children with ASD was more often related with self-absorbed activities and less towards their social partners. Yirmiya, Kasari, Sigman, and Mundy (1989) investigated the spontaneous expressions of facial affect among children with ASD, mental retardation and typically developing controls. Facial affect was coded using the Maximally Discriminative Movement Coding System (Izard, 1979). They found that children with ASD displayed more flat and neutral facial affect as compared to controls. Findings also indicated that children with ASD presented a range of incongruous and vague expressions which were not seen in the comparison children.

Bieberich and Morgan (1998) examined facial affect expression in children with ASD (*n*=18) and Down syndrome (*n*=18) between the ages of 5 and 15 years of age. The children along with their mothers were discreetly filmed during a 25 minute play session. The quality of facial expressions in this study was measured by the Minnesota Preschool Affect Rating Scale (MN-PARS; Shapiro, McPhee, Abbott, & Sulzbacher, 1994). In like manner with previous findings, Bieberich and Morgan (1998) reported that children with ASD displayed less positive and more negative affect as compared to the children with Down syndrome during the semi-structured play session with their mothers. They also found that self-regulation was a strong distinguishing factor between both groups. Self-regulation includes components of behaviour expressed during play such as attention, distractibility, object orientation, adaptability and persistence. In summary, Bieberich and Morgan (1998) reported that children with ASD compared to those with Down syndrome showed more impairments in organisational and attentional skills expressed during the play session.

Some studies have looked into parental perceptions of children's emotional expressiveness. For instance, Capps, Kasari, Yirmiya, and Sigman (1993) conducted two studies, one with older high-functioning children with ASD and healthy controls and the second with younger low-functioning children with ASD and matched controls. The results revealed that the children with ASD in both studies were perceived by their parents as displaying more negative than positive affect. While the studies described above suggest that people with ASD may not express affect in the typical way in their everyday interactions, one of the shortcomings of this approach is that the methodology does not permit control over exactly what the child experiences. Specifically, parents themselves may have varying approaches to interaction and differing degrees of expressivity within these interactions. Therefore it is difficult to tease apart the extent to which differences in the behaviour of the interaction partners (parents/ teachers/psychologists etc.)

might have contributed to the observed differences in expressivity amongst the children.

Other studies have investigated the reactions of people with ASD to displays of positive or negative affect in others. Kasari et al. (1993) examined the expression of pride in children with ASD, mental retardation and typically developing controls. The children completed developmentally appropriate puzzles, both with and without praise. The findings revealed that the children with ASD showed satisfaction (i.e. smile) at completing the puzzles, however only a few shared this affect with either the experimenter or the parent as compared to the controls. In addition, children with ASD were found to respond to praise by showing avoidant responses (i.e. turning away).

In addition, Dawson, Hill, Spencer, Galpert, and Watson (1990) examined the affect, social behaviour and eye gaze patterns in naturalistic exchanges between 16 children with ASD and their mothers. The children with ASD were aged between 30 to 70 months while the control group consisted of 16 typically developing children (matched on receptive language ability as measured by the Reynell Verbal Comprehension Scale). The children and their mothers were filmed in three social conditions; *free play* (low communicative demand); *put toys away* (high communicative demand); and *snack time* (face-to-face interaction). The results of the study demonstrated that children from both groups did not differ in the frequency and total gaze time at the mothers' face. In the snack time condition, children did not display frowning behaviour and their display of smiling did not vary between groups. However, it was found that children with ASD were less likely to fuse their affect expression with appropriate eye contact. The researchers suggest that this reflects a qualitative difficulty in merging eye contact and emotional expression concurrently in order to convey communicative intent. This implies that although children with ASD may be able to express emotions as much as others, they may not as easily convey these emotions to people around them. In addition, Dawson et al. (1990) also reported that children with ASD were much less likely to smile in response to their mothers' smiles as compared to the children in the control group. It must be noted however that the children with ASD in this study were low-functioning, with many fulfilling the criteria for mental retardation; hence the differences between groups may not be completely attributable to ASD. The studies reviewed above demonstrate that individuals with ASD show differences in the integration of affect with attention. In particular, they suggest that those with ASD are less likely to display positive affect together with attentional behaviours (e.g. joint attention) as well as eye contact in social situations. Hence it could be conjectured that the view of 'flat' or 'blunted' affect amongst people with ASD may not be due to a deficit in emotional responsiveness per se, rather from sporadic efforts in social referencing which in turn surface as impaired emotion reactions.

In contrast to the studies directly investigating emotional affect, Hobson and Lee (1998) conducted a study assessing 'intersubjective engagement' (said to be a vital aspect of social understanding) of individuals with ASD in a semi-structured condition which filmed the spontaneous or prompted hellos and goodbyes to an unacquainted adult. The results revealed that compared to controls, individuals with ASD displayed less spontaneous verbal and nonverbal gestures of hellos and goodbyes. Furthermore, they also showed less eye contact when offered a greeting. By the same token, Attwood, Frith, and Hermelin (1988) demonstrated that children with ASD are generally less emotionally expressive in social situations and have difficulty understanding simple instrumental social gestures compared to children with Down syndrome and mental retardation. This was coupled with the finding that children with ASD did not use any expressive gestures (i.e. gestures signalling own inner states or in response to the inner states of others such as consolation and embarrassment) while they did display the use of instrumental gestures (i.e. gestures used to prompt immediate action such as 'be quiet' and 'come here'). On the other hand, Ponnet, Buysse, Roeyers, and Corte (2005) found that the expressive behaviours (as measured by displays of gazing, stimulatory gestures and verbalisations) of individuals with ASD did not differ significantly from healthy controls during initial conversations with a typically developing stranger.

The literature reviewed above indicates that individuals with ASD do make expressive responses but they may be attenuated in their intensity, and different kinds of behavioural responses may be combined in atypical ways (such as gestures, eye gaze and facial expressions). Studies have either analysed posed expressions which may tell us relatively little about how individuals with ASD express themselves in daily life; or they have observed children behaving in naturalistic or semi-structured settings which closely approximate the demands of real life but lack experimental control. In most cases, the expressions produced have been 'coded' by raters for their affective content or expressivity. As yet (to the researcher's knowledge), there has been no experimental study examining expressions of people with ASD. Moreover, almost all of the previous studies have involved children with ASD and little is known about the expressive behaviour of adolescents and adults with ASD.

The experiment described in this chapter operates with the same paradigm used in the previous two experiments (i.e. as described in Chapter 3 and Chapter 4) to address these gaps in our knowledge. However in this study, individuals with ASD were subjected to the four scenarios and their naturalistic responses were surreptitiously filmed. The primary aim was to investigate the ability of typically developing adults to determine which scenario individuals were responding to by viewing brief dynamic video clips of individuals with ASD and matched healthy controls. As in the previous experiments, the advantage of this method is that there is an objectively correct answer to this question; no ratings of emotional expressivity or labelling of mental states is involved. Can people distinguish the scenarios to which the targets responded and are there any differences in people's performance in identifying the scenarios when watching clips of people with ASD vs. typically developing individuals?

5.2 Methods

The entire procedure was approved by the Ethics Committee, School of Psychology, University of Nottingham.

5.2.1 Stimulus Development

Target Reaction Videoclips

The primary aim of this phase of the study was to create video stimuli to be used in the Main Experiment. The same procedure used in creating target reaction stimuli for the previous studies was employed here. Participants (from now on referred to as targets) were informed that they would be filmed while modelling several facial expressions to act as stimuli for another study. However the targets were unaware that the actual purpose was to film their natural reactions to an aspect of the researcher's behaviour that occurred prior to recording the posed facial expressions. Further details are presented below.

Participants

Forty males aged between 13 and 21 (mean age= 15.4 years) were filmed responding to a seemingly incidental aspect of the researcher's behaviour. All targets were native speakers of the English language. Targets with ASD (*n*=20) were enlisted from educational establishments in the United Kingdom and were all British nationals. Written informed consent was obtained from the teachers of targets with ASD. Targets with ASD were officially evaluated by mental health professionals according to the DSM-IV criteria (American Psychiatric Association, 2000) and consequently received a Statement of Special Education Needs for Autism or ASD. Neurotypical targets (*n*=15) were recruited from an international school in Malaysia. Written informed consent was obtained from the parents of neurotypical targets. All targets (both ASD and neurotypical) were involved in either General Certificate of Secondary Education (GCSE), A-Levels or tertiary education courses. Five additional neurotypical individuals from the Stimulus Development stage in the previous study (see section 3.2.1- Target Reaction Videoclips) were included in this study. Of the 20 neurotypical targets, there were 15 British nationals, 3 Australians, 1 Polish and 1 French national. The ASD and neurotypical target groups were all Caucasian and matched for chronological age. This was to ensure that any differences in participants' ability to determine the scenarios to which targets with and without ASD responded were not due to age or race of the targets. All targets completed the Empathy Quotient (EQ; Baron-Cohen & Wheelwright, 2004). An independent-samples *t*-test showed that the neurotypical targets had higher EQ scores than the ASD targets, $t(38) = -2.4$, $p = .02$.

	ASD Mean (*SD*)	Neurotypical Mean (*SD*)
N	20	20
Age	15.7 (2.27)	16.6 (3.32)
EQ	31.45 (9.52)*	38.7 (9.59)*

Table 5.1: Target participant characteristics.
* Significant difference between groups, p < .05

Materials and Apparatus

A large and quiet room within the respective institutions was used for the filming procedure. In order to avoid any disruptions, targets were seated in front of a plain wall with their back towards the main entrance and windows. A Sony DCR-SR60 video camera was placed about 1.7 meters directly opposite the target participant across the table on a tripod. The camera was set up in order for the targets' face and upper body be filmed. The researcher was seated next to the tripod.

Procedure

Targets were informed that they would be filmed while enacting certain facial expressions which would be used as video stimuli in a later study. The same four scenarios (Joke, Story, Compliments & Waiting) were used with the aim of provoking an array of natural behavioural responses from the targets (please refer to Chapter 3 section 3.2.1 for full description of the scenarios). The primary focus was to create scenarios that would elicit a reaction but would be unlikely to cause a change in the mood of the participants. It was imperative that target participants were unaware that the researcher was acting; as such it was essential that the scenarios appeared believable within the context of the experiment. The four different scenarios were randomised between targets in each group, such that five individuals in each group experienced each scenario. Each target experienced only one of the scenarios.

Editing

The video recordings were edited using Windows Live Movie Maker software. A set of editing criteria was developed in order to facilitate objective procedures across both neurotypical and ASD target groups. For each of the scenarios the aim was to generate videoclips that covered the period of time when neurotypical targets showed the greatest response to the event. The Compliments footage was edited to begin at the end of the last said compliment, while the Joke recordings was edited at the point at which the researcher said "*on a crash diet!*". The Story and Waiting footage was edited approximately three seconds before the end of the scenario enactment. Refer to Figure 5.1 for samples of neurotypical target reactions and Figure 5.2 for samples of ASD target reactions. There was a total of 40 edited videoclips (20 for each group with a total of 5 clips per scenario for each group) with a mean of 7.22 seconds. The mean videoclip length in seconds for the neurotypical target group were; Joke: 7.12 (*SD*=.77); Waiting: 7.08 (*SD*=.65); Story: 7.24 (*SD*=.18); Compliments: 7.22 (*SD*=.10). A one-way ANOVA revealed that videoclip length did not differ with the scenarios (*p*=.98). The videoclips for the ASD target group had means of; Joke: 7.18 (*SD*=.18); Waiting: 7.16 (*SD*=.25); Story: 7.3 (*SD*=.12); and Compliments: 7.44 (*SD*=.44). Similarly, it was found that videoclip length did not systematically vary with the scenarios (*p*=.385). Four independent samples *t*-tests examining each scenario across the target groups showed that videoclip length did not differ between groups (all *ps* >.431).

The videoclips were 1080 pixels in width and 720 pixels in height, presented at 25 frames per second. Similar to the previously used videoclips, targets' verbalisations (i.e. auditory component of footage) were not included in the edited videoclips as in many cases it would have disambiguated the scenario entirely.

Figure 5.1: Sample screenshots of neurotypical target reaction videoclips.

Figure 5.2: Sample screenshots of ASD target reaction videoclips.

5.2.2 Main Experiment

Participants

Thirty participants (15 males and 15 females) aged between 18 and 35 (mean age= 23.2 years) took part in this phase of the study. Participants were largely recruited from University of Nottingham Malaysia Campus while others were volunteers from the community. Participants were of several nationalities: 26 Malaysian, 2 Pakistani, 1 British and 1 Chinese national. All participants spoke English as their first language. Participants completed the EQ (Baron-Cohen & Wheelwright, 2004) with a mean score of 39.3 (*SD*=8.0). All participants provided written informed consent. Participants were compensated with an inconvenience allowance for their involvement in the study.

Materials and Apparatus

The same four video-recordings of the researcher performing each of the four scenarios (while looking directly at the camera) were used in this study (see Chapter 3 section 3.2.1 for further details).

The main stimuli for this study were the 40 target behavioural response videoclips from the Stimulus Development phase of this study. All videoclips (both the researcher enacting the scenarios and targets' behavioural responses) were shown on a 15 inch laptop monitor. The target reaction videoclips were presented using PsychoPy2 version 1.74 which randomised the order of presentation. Each videoclip was interspersed with a rectangular image of the four scenario names (i.e. *Joke, Waiting, Story, Compliments*) in black font on white background. The rectangular shaped image was divided equally into four parts for each scenario name. Consistent with the coloured borders in the scenario videoclips, the perimeters enclosing each scenario name in the image had the same corresponding coloured borders. This was done in order to assist memory recall of the scenario videoclips as enacted by the researcher. The 40 behavioural response videoclips did not have coloured borders.

Design

A within-subjects design was employed, whereby all participants watched the four scenario videoclips followed by the 40 target reaction videoclips.

Procedure

Every participant was assessed individually. They were first shown the researcher enacted scenario videoclips which were randomised by PsychoPy2. The purpose of showing the scenario videoclips was for participants to familiarise themselves with the experience of the targets in the Stimulus Development phase, hence having good knowledge of what each scenario involved. Participants were subsequently shown the 40 target behavioural response videoclips, again randomised by PsychoPy2. After each videoclip was presented, the scenario names image appeared on the screen and participants were instructed to state which scenario the target in the videoclip was reacting to by pointing to the screen or directly verbalising the answer. The image stayed on the screen until the participant gave an answer to the previously presented target behavioural response videoclip. The researcher asked, “Which of these events had just happened?” while pointing to the image on the screen. Participants’ responses were documented on data sheets by the researcher. Importantly, no indication was given to the participants that some of the individuals in the videos had an ASD. The participants then filled out the EQ questionnaire. Participants were then debriefed and it is important to note that all participants reported being unaware that half the videoclips presented contained targets with ASD.

5.3 Results

5.3.1 Were participants able to correctly identify the scenarios which targets reacted to?

The aim of the analysis was to determine whether participants could distinguish targets responding to each of the four scenarios as well as if there were differences in their ability in identifying scenarios for the neurotypical and ASD target videoclips. Signal detection method was utilised to analyse participants’ responses (refer to section 3.3.1 for description). In this study, the neurotypical and ASD target videoclips (i.e. 20 videoclips in each group) were analysed separately by computing the hit rate for the responses to the five videoclips showing reactions to a particular scenario whereas false alarm rate was computed for the responses to the remaining fifteen videoclips which did not depict the scenario in question.

Eight one-sample *t*-tests with Bonferroni adjusted alpha level of .0063 were conducted. It was found that participants were able to correctly discriminate which scenario neurotypical targets were responding to as *d*’ scores were significantly greater than 0 for all four scenarios [Joke *t*(29)=9.69, *p*<.001; Waiting *t*(29)=16.98, *p*<.001; Story *t*(29)=8.96, *p*<.001; Compliments *t*(29)=7.20, *p*<.001]. Conversely, only the Joke [*t*(29)=9.69, *p*<.001] and Waiting [*t*(29)=16.98, *p*<.001] scenario clips yielded *d'* scores significantly larger than 0 when viewing the videoclips of ASD targets. Participants were not able to distinguish reactions to the Story [*t*(29)=1.13, *p*=.267] and Compliments scenarios [*t*(29)=2.03, *p*=.056] when watching videoclips of targets with ASD. Please refer to Figure 5.3 for participant mean *d'* scores and Table 5.2 for participant mean accuracy and false alarm rates.

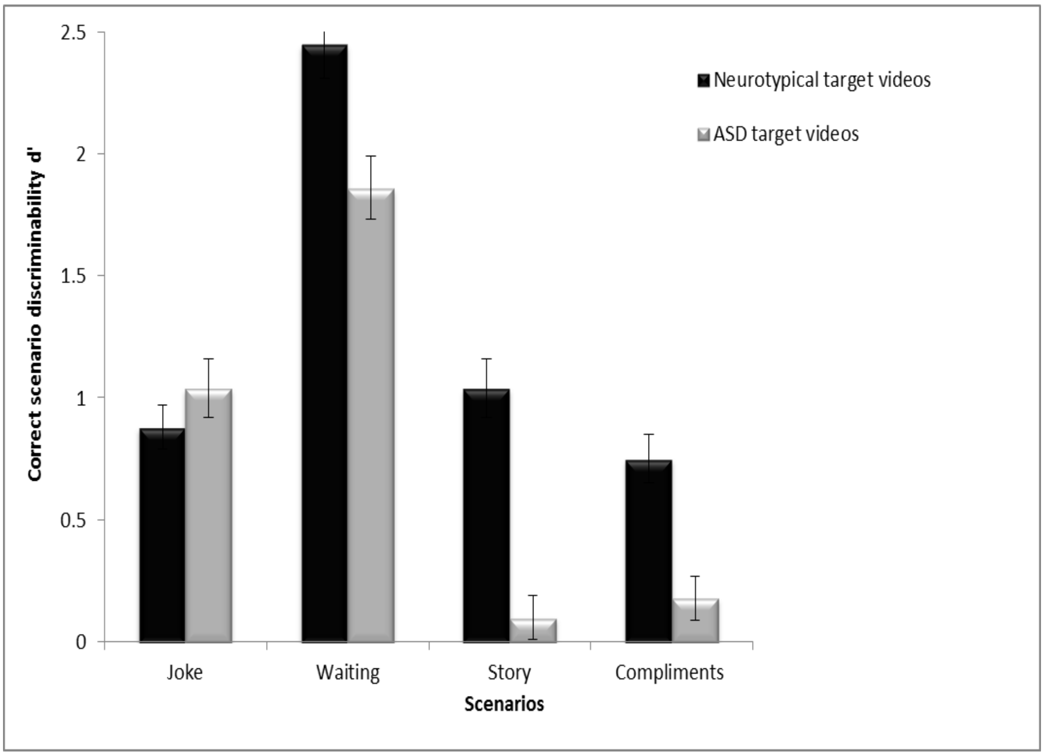

Figure 5.3: Correct scenario discriminability across neurotypical and ASD target videoclips (mean d' score).
(Error bars represent standard errors of the mean)

	Neurotypical videoclips		ASD videoclips	
	Accuracy	False alarm	Accuracy	False alarm
Joke	1.73 (34.6%)	1.47 (9.8%)	2.00 (40.0%)	1.33 (8.87%)
Waiting	4.33 (86.6%)	.97 (6.5%)	4.27 (85.4%)	2.50 (16.7%)
Story	2.50 (50.0%)	2.10 (14.0%)	1.50 (30.0%)	4.13 (27.5%)
Compliments	2.67 (53.4%)	3.60 (24.0%)	1.07 (21.4%)	2.87 (19.1%)

Table 5.2: Participant mean accuracy rates and false alarm rates.

Accuracy : Number correct out of 5 (% in brackets)
False alarm: False alarms out of a possible 15 (% in brackets)

Chi-square analyses were performed to investigate participants' pattern of error responses. Four separate chi-square analyses were performed for each scenario in both the neurotypical and ASD target video groups. Table 5.3 shows participants' error responses when viewing videos of neurotypical targets. Findings showed that when participants watched neurotypical target videos, their error responses were not equally distributed for reactions to the Joke scenario [$X^2(3, n= 93) = 66.84$, $p < .001$] which was most often mistaken for reactions to the Compliments scenario. Their error responses were not equally distributed for reactions to the Waiting scenario [$X^2(3, n= 11) = 7.82$, $p = .02$], which tended to be confused with reactions to the Story scenario. Their error responses were also not equally distributed for reactions to the Compliments scenario [$X^2(3, n= 67) = 16.6$, $p < .001$], which tended to be confused with both the Story and Joke scenarios, but seldom the Waiting scenario. Finally, their error responses were not equally distributed for reactions to the Story scenario [$X^2(3, n= 70) = 9.29$, $p = .009$] which were most often mistaken for reactions to the Compliments scenario.

	Joke	Waiting (observed error responses)	Compliments	Story	Expected error responses
Joke	-	5	67	21	31
Waiting	1	-	2	8	3.67
Compliments	27	7	-	33	22.33
Story	15	20	35	-	23.33

Table 5.3: Participant error response distribution when viewing neurotypical target videos (in frequencies).

Similarly, it was found that when participants watched ASD target videos, their error responses were not equally distributed in all scenarios. Participants tended to mistake reactions to the Joke scenario [$X^2(3, n= 86) = 25.42$, p <.001] for the Compliments scenario. They tended to mistake reactions to the Waiting scenario [$X^2(3, n= 20) = 9.7$, p =.007] for reactions to the Story scenario. They most often mistook reactions to the Compliments scenario [$X^2(3, n= 115) = 49.58$, p <.001] for the Joke scenario. Finally, they confused reactions to the Story scenario [$X^2(3, n= 106) = 8.85$, p =.001] for reactions to the Waiting and Compliments scenarios. Table 5.4 shows participants' error responses when viewing videos of ASD targets.

	Joke	Waiting (observed error responses)	Compliments	Story	Expected error responses
Joke	-	13	27	15	28.67
Waiting	7	-	0	14	6.67
Compliments	71	12	-	16	38.33
Story	16	27	25	-	35.33

Table 5.4: Participant error response distribution when viewing ASD target videos (in frequencies).

5.3.2 Were there differences in participants' ability in identifying scenarios when watching videoclips of neurotypical vs. ASD targets?

A 2x4 (target group x scenario) repeated measures ANOVA was performed in order to examine whether there were differences in participants' abilities in identifying the scenarios responded to in the neurotypical and ASD target videos. A main effect of video group was found, $F(1,29)=38.16$, $p<.001$, which shows that participants were better at identifying the scenario responded to when viewing the videoclips of neurotypical targets as compared to the videoclips of targets with ASD. A main effect of scenario was also found, $F(3,87)=100.15$, $p<.001$. Posthoc *t*-tests with Bonferroni correction revealed that participants were better at differentiating targets responding to the Waiting scenario than the other three scenarios (all *ps*<.001). It was also found that responses to the Joke scenario were easier to identify than the Story and Compliments scenarios ($p<.001$). However participants showed no significant differences in the identification of responses to the Story and Compliments scenarios ($p=1.0$). In addition, a significant interaction effect between scenario and target group was found, $F(3,87)=13.78$, $p<.001$; indicating that the effects of scenario differed for the two target groups. To further investigate this interaction, separate one-way ANOVAs were performed to examine the effect of the scenario responded to on correct discriminability for the neurotypical and ASD target groups. There was a significant effect of the scenario reacted to in the videoclips of neurotypical targets, $F(2.19,63.46)=62.10$, $p<.001$ (Greenhouse Geisser corrected). Posthoc *t*-tests with Bonferroni corrected alpha level of .0125 revealed that participants better identified responses to the Waiting scenario than the remaining three scenarios (all *ps*<.001). Similarly for the videoclips showing targets with ASD, a significant effect of scenario responded to was found, $F(3,87)=70.37$, $p<.001$. Posthoc *t*-tests with Bonferroni corrected alpha level of .0125 showed that participants again found the Waiting scenario easier to identify as compared to the other three scenarios (all *ps*<.001). They were also better at discriminating responses to the Joke scenario compared to the Story and Compliments scenarios (all *ps*<.001). The interaction was further examined using paired sample *t*-tests to assess the effect of target groups (neurotypical and ASD) for each scenario response. Participants were better at discriminating the videos showing neurotypical compared to the ASD targets reacting to the Waiting, $t(29)= -5.19$, $p< .001$; Story, $t(29)= -7.14$, $p< .001$; and Compliments scenarios, $t(29)= -4.09$, $p< .001$. However, findings revealed that participants identified reactions to the Joke scenario equally for videos of neurotypical and ASD targets, $t(29)=1.13$, $p=.278$.

5.3.3 Were participants' EQ scores related to their ability to correctly discriminate between reactions to the scenarios?

It was then investigated if there was a relationship between participants' reported empathic traits (i.e. EQ score) and their ability in distinguishing the scenarios targets in the videoclips were reacting to. Four separate Pearson product-moment correlations with Bonferroni correction (alpha level .0125) were conducted. No significant relationships between mean EQ score and mean *d'* scores (correct scenario discriminability) were found (Joke: *r*=.12, *n*=30, *p*=.519; Story: *r* =.35, *n* =30, *p*= .058; Compliments: *r* =.24, *n* =30, *p*= .204; and Waiting: *r* =.37, *n* =30, *p*= .045).

The same analyses mentioned above were then conducted for each target group (separate Pearson product-moment correlations with Bonferroni correction). When individuals viewed videos of the neurotypical targets, no relationships were found between participant reported empathic traits and ability to discriminate which scenario they were reacting to for all scenarios (Joke: *r*=-.17, *n*=30, *p*=.375; Story: *r* =.329, *n* =30, *p*= .076; Compliments: *r* =.15, *n* =30, *p*= .432; and Waiting: *r* =.28, *n* =30, *p*= .131). Similarly, when individuals viewed videos of targets with ASD, no relationships were found in participant EQ scores and their ability to correctly discriminate the scenarios (Joke: *r*=.29, *n*=30, *p*=.123; Story: *r* =.20, *n* =30, *p*= .284; Compliments: *r* =.19, *n* =30, *p*= .346; and Waiting: *r* =.40, *n* =30, *p*= .031).

This shows that participants' empathic scores were not correlated with their ability to determine the scenario to which neurotypical and ASD targets responded to.

5.3.4 Did the EQ scores of targets affect participants' ability to deduce what had happened to them?

The relationship between the EQ scores of neurotypical and ASD targets and participants' abilities to correctly identify the scenario to which they responded was investigated. As it is probable that targets' expressiveness is a factor in people's ability to guess the scenario a target is reacting to, it can also be conceived that individuals who have a higher EQ score and are more emotionally attuned with others may in fact be more expressive themselves. Table 5.5 and Table 5.6 show targets' mean EQ scores and participants' correct scenario discriminability, broken down by scenario. The accuracy rates are the percentage of participants who successfully identified the scenario from the videoclips ([number of participants who accurately identified the scenario in the videoclip ÷ 30] x 100). There were a total of 20 videos in each target group (i.e. 5 videos for each of the 4 scenarios).

	Target EQ scores	Participant accuracy
	Mean (*SD*)	Means in percentage (*SD*)
Joke	29.2 (6.7)	37.3% (5.5)
Waiting	39.4 (11.1)	92.0% (5.6)
Story	41.6 (6.5)	51.3% (18.6)
Compliments	44.6 (7.6)	53.3% (24.6)

Table 5.5: Neurotypical targets' mean EQ scores & participants' accuracy rates.

	Target EQ scores	Participant accuracy
	Mean (*SD*)	Means in percentage (*SD*)
Joke	28.2 (11.2)	39.3% (21.5)
Waiting	32.8 (8.2)	84.0% (19.4)
Story	28.0 (8.0)	28.7% (14.1)
Compliments	36.8 (10.4)	21.3% (27.4)

Table 5.6: ASD targets' mean EQ scores & participants' accuracy rates.

Neurotypical targets (*M*= 38.7, *SD*= 9.6) had significantly higher EQ scores than targets with ASD (*M*= 31.5, *SD*= 9.5), $t(38)=-2.4$, $p=.023$. A one-way between groups ANOVA was conducted to explore whether there were differences in target EQ scores in the different scenarios. As participants were allocated to the four scenarios in an unbiased way, it was expected that no differences would be found in EQ scores for those experiencing each scenario. Accordingly, no significant differences in EQ scores between scenarios were found in targets with ASD (*F*(3,16)=.97, *p*=.437). However, there was a statistically significant difference in EQ scores between scenarios experienced by neurotypical targets (*F*(3,16)=3.3, *p*=.052). Posthoc *t*-tests showed that neurotypical targets who experienced the Compliments scenario had significantly higher EQ scores than participants who witnessed the Joke scenario (*p*=.051).

A 2 by 2 between-group analysis of covariance was conducted to explore whether the target video group differences remained when target EQ scores were controlled for. A significant main effect was found for target video group [*F*(1,31)=6.14, *p*=.019] which suggests that the effect of target group is not explained by any group differences in EQ. This indicates that the variability in EQ found between and within the ASD and neurotypical targets is not driving the differences between the groups.

5.4 Discussion

The aim in this chapter was to investigate people's ability to correctly identify the scenario reacted to when presented with videoclips of typically developing targets as well as targets with ASD. In concordance with the findings in Chapter 3 (Experiment 1), it was found that people successfully inferred the four scenarios when watching videoclips of neurotypical targets. What about people's ability to distinguish the scenarios when presented with videoclips of targets with ASD? For the most part, the results indicate that individuals successfully deduced the scenarios reacted to in ASD target videoclips to a certain degree, with the exception of the Story and Compliments scenarios. For all scenarios participants were less successful for ASD than neurotypical targets aside from the Joke Scenario.

The findings challenge the archaic standpoint that ASD entails the "absence of emotional reaction" as was described in the DSM-III (American Psychiatric Association, 1987, p. 35) as they generally show that individuals with ASD do make expressive responses, and in at least one scenario (i.e.

Joke) their reactions were as easy to interpret as their typically developing peers. On the other hand, for the remaining three scenarios, people found it harder to guess the scenario responded to by targets with ASD than by those without. A plausible explanation for this may be that individuals with ASD are generally less expressive as compared to typically developing individuals, perhaps exhibiting more flat and neutral affect (Yirmiya et al., 1989). Moreover it has also been suggested that elements such as language and emotional expressions in naturalistic social interactions may cause overstimulation for individuals with ASD due to the capricious and multifaceted nature of the stimuli, which in turn can result in the loss of interest or reduced attention to the stimuli (Dawson & Lewy, 1989). This explanation would imply that those with ASD produce a qualitatively similar response but with less intensity than neurotypical individuals. However an alternative explanation is that the targets with ASD responded in qualitatively different ways from the neurotypical targets in some scenarios, rendering their reactions difficult to interpret. The question remains as to how people successfully deduced the Joke scenario and the Waiting scenario to some extent but not the Story and Compliments scenarios when watching videoclips of targets with ASD.

Why did the Story and Compliments scenarios elicit uninterpretable behavioural responses in targets with ASD? Though the exact mental states experienced by the targets are not the central point of interest in the study, one might speculate how people may have felt in these two scenarios in order to make sense of their subsequent behavioural responses. It is reasonable to conjecture that in the Story scenario most targets would empathise by showing understanding or offering comfort to the researcher (although others may feel uncomfortable with the sharing of personal information, while there may be some who are plain uninterested). If it were the case that the Story scenario evoked a mental state of empathy amongst the majority of targets, this would make for a compelling case for why targets with ASD produced unusual responses to this scenario. Multiple studies have shown that individuals with ASD have difficulties in empathising (e.g. Baron-Cohen & Wheelwright, 2004). Studies have shown that typically developing infants as young as three months are able to tune their emotional reactions in accordance to the responses of others (Bertin & Striano, 2006). Furthermore in their review, Roth-Hanania, Busch-Rossnagel, and Higgins-D'Alessandro (2000) stated that toddlers and pre-schoolers can display more advanced empathic responses such as showing comfort in order to influence one's emotional state. On the other hand, individuals with ASD often respond to the emotional expressions of others with less interest, offer a reduced amount of comforting behaviour and on the whole communicate less affect with their interaction partners (Kasari, Sigman, Mundy, & Yirmiya, 1990; Sigman, Kasari, Kwon, & Yirmiya, 1992).

This may be because those with ASD have fundamental difficulties simulating the mental states of others. Lynne Soraya, a disability advocate and writer with Asperger's Syndrome, fittingly stated "I absolutely understand that other people have their own plans, thoughts, and points of view — but those plans, thoughts and points of view are often a mystery to me. 'Putting myself in someone else's shoes' would have me doing something very different than what another person might envisage doing in a similar situation" (Soraya, 2008). Studies have shown that individuals with ASD have deficits in empathy-related processes such as emotional contagion (i.e. the production of meaningful affect in individuals who view the emotional responses of others) as well as the swift and spontaneous mimicry of emotional expression (Stel, van den Heuvel, & Smeets, 2008). Clark, Winkielman, and McIntosh (2008) examined people with ASD, reading disability and typically developing individuals in their ability to detect mental states from faces (happy or angry), gender from neutral faces (male or female) and neutral non-face stimuli (animal or object). Participants were presented with images for 15 and 30 microseconds, which is typically the range of micro-expressions. They found no group differences in identifying gender and animal-object conditions, however individuals with ASD performed significantly worse than the controls in the mental state condition. They further noted that this deficit persisted even after controlling for age, gender and verbal ability and was not accounted for by concessions in speed and accuracy. Clark et al. (2008) highlighted the importance of rapid emotional processing in functional everyday social-communication and stated that the inadequacies in rapidly processing emotional information may contribute to the challenges people with ASD experience in empathy and mimicry. Hence in the Story scenario, the targets might have had difficulties in swiftly processing multiple channels of information (e.g. context of story, researcher's body language, facial affect) which may have in consequence resulted in diminished ability to engage in mimicry and empathic related behaviours.

In regards to the Compliments scenario, some neurotypical targets may have felt flattered, while a handful perhaps a little confused and others may have been embarrassed or experienced a sense of pride. As mentioned in Chapter 1, embarrassment and pride are types of self-conscious emotions which individuals with ASD seem to have difficulty recognising. Colonnesi, Engelhard, and Bögels (2010) proposed that mentalising ability is an important component in the development of self-conscious emotion attribution to self and others. In order to experience embarrassment, one must have a representation of another's mind (Burnett, Bird, Moll, Frith, & Blakemore, 2008), encompassing the understanding of social norms and conventions as well as the awareness of others' evaluation (Tager-Flusberg, 1999). Hillier and Allinson (2002) found that mentalising ability and the understanding of embarrassment was correlated among adults with high-functioning ASD. If the targets with ASD did not experience these self-conscious emotions then this might explain the difficulty neurotypical participants had in detecting their responses to the Compliments scenario.

Participants' ability to identify reactions to the Joke scenario to the same degree in both neurotypical and ASD target videos suggest that the behavioural responses of targets from both groups contained the same degree of useful information. It is plausible that the targets with ASD may have an understanding of humour given the simplicity of the joke presented. A classic study by Ricks and Wing (1975) showed that children with ASD have the ability to comprehend simple jokes and slapstick comedy. In addition, Van Bourgondien and Mesibov (1987) demonstrated that adults with high-functioning ASD were able to tell jokes that were at a lower grade of humour level than their developmental level. For instance, many individuals with ASD found it possible to understand pre-riddles and jokes that were based on phonological and lexical inconsistencies. Studies have also shown that children with ASD are able to create and appreciate humour to a certain extent in a naturalistic setting, though at a lower level compared to matched controls (St James & Tager-Flusberg, 1994). As the joke expressed in the scenario was simple and straightforward, it is possible that targets with ASD understood the joke, and responded in broadly similar ways to neurotypical individuals. Nonetheless it must be noted that even though there was no differences in the identification of responses to the Joke scenario for the neurotypical and ASD target groups, the joke still elicited a variety of responses such as giggling, fake smile, rolling of the eyes, as well looking baffled or discontented.

Similar to the findings in Chapter 3 (Experiment 1), no relationship was found between participants' self-reported empathising abilities (i.e. EQ ratings) and correct scenario identification when viewing videoclips of neurotypical targets. It was also found that the targets' self-reported empathic traits did not influence participants' ability to correctly distinguish the scenarios (similar to the findings in Experiment 1 and 3). However, it should be noted that the number of targets in each group was small so correlations need to be interpreted with caution. This suggests that individual differences in empathic abilities and the ensuing behavioural response do not necessarily have an impact on people's ability to infer one's behavioural reaction.

A final outstanding question is whether the difference in the behavioural responses of targets with ASD reflects differences in expressivity of the same internal states (be it qualitative or quantitative differences) or whether they reflect fundamental differences in the actual underlying mental states felt. The ability of individuals with ASD for understanding affect shows disparities when compared with typically developing individuals. Hill, Berthoz, and Frith (2004) reported that individuals with ASD had difficulties in distinguishing and describing their own emotions, a condition sometimes referred to as alexithymia. Similarly, it has been shown that children with high-functioning ASD have problems characterising their own emotions and had less developed conceptions of emotion (Rieffe, Meerum Terwogt, & Kotronopoulou, 2006). Losh and Capps (2006) looked into the emotional understanding of 50 children aged between 7 and 13 years of age (28 with high- functioning ASD and 22 healthy controls). The paradigm they employed comprised a discourse analytic framework designed to assess the participants' approach to construing emotional and non-emotional situation circumstances. Participants' responses were evaluated for dialogue structure and thematic content. They found that while the group with ASD were able to provide contextually applicable interpretations of simple emotions (e.g. happy, sad, afraid) and non-emotions (e.g. tired, sick); they were less able to provide proper descriptions of complex emotions (e.g. curious, disappointed) and self-conscious emotions (e.g. embarrassed, guilty, ashamed). They also found that children with ASD were less likely to consolidate their emotional narratives through personalised and causal explanations and were more inclined to describe visibly relevant aspects of their experiences; this was hardly observed amongst healthy controls. The authors stated that although children with ASD are able to distinguish appropriate contexts for simple emotions, they generally have less articulate accounts of emotional experiences and employ different strategies to interpret emotionally charged situations.

Such findings could be taken as support for the notion that the mental states of those with ASD may be subjectively different from those of neurotypical individuals. On the other hand, it has also been suggested that the facial feedback mechanism (i.e. recreated affect when mimicking others' emotional responses) is different in individuals with ASD and that this may be an indicator of the deficit in the connection between felt emotion and expressed emotions (Stel et al., 2008). They suggested that if individuals with ASD display distinctive and attenuated facial expressions, it is a possibility that the association between expressed facial affect and felt emotion has not been properly established in those individuals. Furthermore, the disconnect between felt emotion and expressed emotion would further impact on situations in which another's emotional response may not be directly observable but instead must be inferred i.e. affective mentalising (Hooker, Verosky, Germine, Knight, & D'Esposito, 2008). This in turn would have substantial implications for the understanding and expression of own emotions, as well as the understanding of others' emotions. This is consistent with the idea that those with ASD experience the same mental states as neurotypical individuals but just express them differently. Whatever the case, given that there is no way to measure their mental states directly, inferences must always be made indirectly from some form of behaviour. Advances in neuroimaging may facilitate the process of coming closer to being able to answer this question.

CHAPTER 6

General Discussion and Conclusion

6.1 Research Overview

Mentalising was brought to the forefront of research with Premack and Woodruff's (1978) classic study involving chimpanzees. A chimpanzee was shown a series of filmed scenes of an actor struggling with several problems of varying difficulty. For instance, trying to get hold of bananas which were out of reach as well as attempting to escape from a locked cage. The chimpanzee was then presented with two images depicting two different subsequent actions, only one of which was the correct action to solving the previously presented problem. Premack and Woodruff (1978) reported that the chimpanzee reliably selected the accurate solutions to the presented problems a majority of time hence implying that the chimpanzee ascribed mental states to the actor. Baron-Cohen, Leslie and Frith (1985) described mentalising as the ability to ascribe mental states such as intentions, desires and beliefs to oneself and others. Techniques for assessing mentalising have evolved considerably over the years, from the use of standard first-order false-belief tasks (e.g. Wimmer & Perner, 1983), to second-order false-belief tasks (e.g. Perner & Wimmer, 1985) as well as advanced mentalising tasks (e.g. Happé, 1994) in order to examine people with higher mentalising abilities. While some studies utilising the abovementioned tasks have shown that individuals with ASD have the ability to infer the mental states of others (Rutherford & Towns, 2008) others have shown that they have significant difficulties compared to healthy controls in identifying certain mental states (Law Smith, Montagne, Perrett, Gill, & Gallagher, 2010). Another recent development is Baron-Cohen, Jolliffe, Mortimore and Robertson's (1997) idea that mental states are directly discernible from people's behaviour, contrary to Premack and Woodruff (1978). In particular, some evidence suggests that the eye region of the face is vital in the identification of mental states (Smith, Cottrell, Gosselin, & Schyns, 2005) and that people with ASD have a tendency to look less at this region and consequently are less able to use information from the eyes (Corden, Chilvers, & Skuse, 2008). On the other hand, there has also been counter-evidence to suggest that the mouth region is essential in the recognition of mental states through dynamic facial expressions (Blais, Roy, Fiset, Arguin, & Gosselin, 2012).

Nonetheless the majority of research conducted in the area of mentalising has lacked an essential component- the representation of the naturalistic social world which resembles the context in which mentalising skills are often employed. A large number of mentalising studies utilise posed static pictures depicting extreme expressions (e.g. Tanaka, Kaiser, Butler, & Le Grand, 2012); not representative of actual day-to-day social interactions. Under these circumstances, it is not surprising that the true capabilities of individuals with and without ASD to mentalise are still shrouded with uncertainty. The primary aim in this thesis was to investigate the mentalising abilities in individuals with and without ASD using a task that more closely approximates some of the demands of the social world.

Are people with and without ASD able to deduce the mental states of others in a naturalistic context? While a large body of research has focussed on the ability to predict future behaviour as an indicator of mentalising ability (e.g. Senju, Southgate, White, & Frith, 2009), an alternate way of evaluating mentalising ability involves 'retrodiction', (Gallese & Goldman, 1998) which is a sort of backwards deduction from a mental state to its underlying precursor. Milikan (2005) explained that people seldom use mental states to predict behaviour in real life as we often only learn of a person's mental state after the behaviour has occurred. As such retrodictive mentalising serves an important social utility; that is, to understand and make sense of others' behaviours as we observe or learn about them. With this in mind, a novel retrodictive mentalising task was developed to measure mentalising abilities of individuals with and without ASD. Chapter 3 described the newly developed mentalising task and investigated the performance of typically developing individuals in this task. Then in Chapter 4, the retrodictive mentalising ability of individuals with and without ASD was examined. The experiment in Chapter 5 subsequently investigated people's mentalising ability when viewing videoclips of targets with ASD as well as healthy controls.

Were people with ASD able to distinguish the correct scenario and did they perform less well compared to their neurotypical counterparts? Did people with ASD look less at the eye region than neurotypical individuals? Was cognitive ability related to task performance? Did participants' and targets' scores on the EQ questionnaire influence performance on the retrodictive mentalising task? Were people able to correctly identify the scenarios when viewing videoclips of targets with ASD? These are some of the questions which were investigated in this thesis. This chapter will start with a summary of experimental findings from each study followed by a discussion of theoretical and practical implications. Thenceforth limitations of the present studies, followed by directions for future research will be considered. Finally overall conclusions will be drawn.

6.2 Summary of Results

6.2.1 Experiment 1 - Can Individuals Guess What Happened to Others from Their Brief Behavioural Responses?

In this study, the ability of typically developing individuals to discriminate between individuals' reactions to four scenarios was examined. Participants viewed videoclips of targets responding to the four scenarios; Joke (being told a joke), Waiting (kept waiting for an experiment to commence), Story (told about a series of mishaps experienced by the researcher), and Compliments (given several compliments in succession). The participants then determined which scenario the target in the videoclip was reacting to. It was found that participants successfully deduced all scenarios – albeit to a limited extent - and were better at identifying reactions to the

Waiting scenario compared to the remaining three scenarios. In addition, reactions to the Story scenario were more easily identified than the Compliments scenario. Participants' eye gaze behaviours were also recorded in this study. Contrary to the hypothesis, it was found that participants looked more at the mouth region as compared to the eye region of the face when viewing target videoclips. Furthermore, findings also suggested that increased gaze time at the eye region was associated with decreased scenario reaction discriminability for the Waiting, Story and Compliments scenarios (and unrelated to the Joke scenario). Participants also completed the Empathy Quotient questionnaire (EQ; Baron-Cohen & Wheelwright, 2004). Surprisingly, it was found that EQ scores did not relate to ability to deduce which scenario targets were reacting in all scenarios. In addition, no relationship was found between eye region gaze time and participant EQ scores. It was then investigated if the EQ scores of targets had an impact on participants' ability to deduce what had happened to them. Findings revealed that target EQ scores did not influence participants' ability in deducing reactions to all scenarios.

Interpretation

Despite the extensive variation of responses, participants' ability to deduce the four scenarios from brief samples of targets' behaviour suggest that they used retrodictive mentalising to come to the correct antecedent of the viewed responses (Gallese & Goldman, 1998). Participants were better at identifying responses to the Waiting scenario in comparison to the other three scenarios. This may be attributed to the inherent nature of the Waiting scenario in itself as additional information such as gestures i.e. looking around and sighing were often included in the target videoclips. On the other hand, behavioural responses to the Joke, Compliments and Story scenarios were somewhat more alike hence increasing the difficulty in discriminating between these scenarios. Participants spent more time looking at the mouth region compared to the eye region of the targets' face in all four scenarios. Furthermore, looking at the eye region was associated with poorer identification of the scenario responded to for the Story, Compliments and Waiting scenarios and was unrelated with success for the Joke scenario. These findings suggest that the eyes are not the most informative facial region when determining what happened to the targets in the videoclips. Instead they indicate that the mouth region provided useful information for the deduction of the scenarios reacted to, consistent with Kirchner, Hatri, Heekeren, and Dziobek (2011) who reported increased fixation time in the mouth region in emotional recognition conditions as well as Cunningham, Kleiner, Bülthoff and Wallraven (2004) who proposed that the mouth area was central in communicating vital information about certain mental states.

It was conjectured that individuals who are good at empathising may have a better understanding of what had just happened to the targets in the videoclips. As such it was expected that empathising scores from the EQ questionnaire would correlate with mentalising performance in this task; however it was not found to be so (with the exception to the rule being the Waiting scenario). This suggests that the EQ questionnaire may not consistently relate well to performance on a naturalistic and subtle mentalising task i.e. scenario identification task. Furthermore, the EQ scores of targets in the videoclips were also not related to participants' ability in identifying all scenarios.

6.2.2 Experiment 2 - Did the Waiting and Story Scenarios Influence Targets' Responses on the Empathy Quotient (EQ)?

The analysis of target EQ scores revealed a significant difference between EQ scores of the target participants in the Waiting and Story scenarios, with targets in the Story scenario having higher EQ scores on the whole as compared to targets in the Waiting scenario. This was surprising as targets had been allocated to the different scenarios in an unbiased fashion and hence it had been assumed that those in each scenario would have similar EQ scores. This study was conducted to examine whether the scenario experienced by participants could have influenced the way in which they responded to the subsequently presented EQ questionnaire. Is it possible that the people in the Waiting scenario felt annoyed or angry as they were kept waiting and consequently answered the EQ in an unempathic manner? Meanwhile could it be that individuals subjected to the Story scenario felt empathy for the researcher as she narrated the mishaps she experienced and subsequently completed the EQ questionnaire in a similar manner? The present study aimed to examine the relationship between experiencing the Story and Waiting scenarios and EQ scores. New targets were recruited and they experienced either the Story or the Waiting scenario then completed the EQ. Findings showed that there was no difference in EQ scores between individuals experiencing the Story and Waiting scenarios suggesting that the scenario experienced did not influence the way in which targets in Experiment 2 responded to the EQ questionnaire.

Interpretation

Differences were found in the way in which targets from the Story and Waiting scenarios in Experiment 1 responded to the EQ questionnaire; however these findings were not replicated in the current study. This suggests that the scenario experienced does not impact on how people self-report their level of empathic ability. As targets were randomly allocated into the respective scenario groups, the difference in reported EQ scores in Experiment 1 appears to be explained by pure chance allocation of people with intrinsically low or high empathic traits to the Story and Waiting scenarios. This is important as it suggests that the EQ did act as a valid measure of empathic traits in Experiment 1, rather than merely a measure of state empathy. It is unlikely that experiencing a brief incident would significantly change one's reporting of empathic traits as the EQ has been shown to be a stable measure with adequate validity and reliability (Muncer & Ling, 2006).

6.2.3 Experiment 3 - Can Individuals with Autism Spectrum Disorder (ASD) Guess What Happened to Others from Their Brief Behavioural Responses?

This study used the same task as in Experiment 1 to investigate retrodictive mentalising in groups of individuals with and without ASD. It was found that both neurotypical and participants with ASD successfully discriminated between target reactions across all four scenarios. Similar to the findings in Experiment 1, all participants identified reactions to the Waiting scenario more easily than the other three scenarios. Furthermore, reactions to the Story scenario approached significance in being more easily identified than responses to the Compliments scenario, again similar to Experiment 1. It was predicted that people with ASD would have more difficulty determining the scenario that the target had experienced compared to their typically developing counterparts. In line with the hypothesis, findings showed that ASD participants were significantly poorer at discriminating between scenarios according to target reactions. Analyses of participant IQ scores revealed that overall scenario discrimination and the identification of reactions to the Compliments scenario were positively associated with full scale IQ scores only in the ASD group.

What were participants' eye gaze behaviours? Findings showed that neurotypical and ASD participants spent more time looking at the mouth compared to the eye region of the targets in the videoclips, with this effect reduced (although not absent) for the Waiting scenario. Importantly, there was no evidence to suggest that the neurotypical and ASD participants varied in their attentional priority for the targets' eyes and mouth. Additionally, findings showed that there were no relationships between eye region and mouth region gaze time and scenario identification. It was found that target EQ scores did not influence people's ability to guess the scenario the target responded to for all scenarios, for both ASD and neurotypical participants.

Interpretation

Consistent with the findings in Experiment 1, participants successfully deduced the scenarios by viewing targets' brief behavioural responses implying that participants with ASD and healthy controls utilised retrodictive mentalising strategies in order to distinguish the scenario which had occurred. Once again, the Waiting scenario was more easily identified than the other three scenarios, likely due to the distinctive responses of the targets in this particular condition. The poorer performance of participants with ASD in discriminating the scenarios compared to neurotypicals is consistent with the suggestion that subtle mentalising deficits can be found in naturalistic tasks which reflect the challenges of everyday social conditions. This is comparable to Sawyer, Williamson and Young's (2012) recent finding that that people with Asperger's Syndrome were poorer at distinguishing complex mental state expressions than neurotypical adults. Similar to the findings in Experiment 1, participants generally spent more time gazing at the mouth compared to the eye region of targets. As the findings of Experiment 1 in this respect were replicated with a fresh sample of participants this implies that this looking pattern is relatively robust and the observed preference for mouth over eyes is genuine.

Furthermore, no differences in gaze at critical regions of the face (eye and mouth) were found for neurotypicals and participants with ASD. This suggests that the difficulty people with ASD have in deducing the scenarios targets responded to is not due to reduced looking at the eye region, contrary to Spezio, Adolphs, Hurley and Piven (2007) who suggested that individuals with ASD do not use information from the eyes. Instead it appears that people with and without ASD look at parts of the face which are most useful for inferring the targets' reaction; however people with ASD are still poorer at making accurate judgements compared to neurotypical individuals.

The relationship between the cognitive ability (IQ) of individuals with ASD and mentalising task performance might suggest that higher-functioning individuals have strategies in place to work out the correct scenarios, albeit less effectively than neurotypical individuals. This stands in contrast to the neurotypical participants in whom task performance was independent of IQ level. Similar to the findings in Experiment 1, no relationships were found between target EQ scores and participants' performance in identifying reactions to the scenarios. This suggests that self-reported empathic abilities and level of expressiveness may not be related. It also implies that EQ scores may not have an impact on actual task performance

6.2.4 Experiment 4 - Can People Determine What Happened to Individuals with Autism Spectrum Disorder (ASD) from Their Brief Behavioural Responses?

Results in Experiment 3 revealed that individuals with ASD compared to neurotypical controls had significant difficulties in correctly distinguishing the scenarios that targets experienced. It was conjectured that one of the ways in which people identify the correct scenario is by 'putting themselves in the other person's shoes', possibly through a process of simulation. However what if it is the case that individuals with ASD are able to simulate adequately but identify the wrong scenarios because they respond in a different way from the targets in the videoclips? This experiment operated with the same paradigm used in Experiment 1 and 3 and asked the primary question- how do individuals with ASD respond to the scenarios themselves? Individuals with ASD (along with matched neurotypical comparison participants) were subjected to the four scenarios and their natural responses were secretly filmed. Participants successfully identified all scenarios responded to when viewing videoclips of neurotypical targets to some extent. However when viewing videoclips containing targets with ASD, participants were only able to identify the Joke and Waiting scenarios at all; and were unable to identify the reactions to the Compliments and Story scenarios. Participants were better at distinguishing the scenarios when viewing neurotypical targets compared to targets with ASD for all scenarios aside from the Joke scenario. Similar to Experiments 1 and 3, the Waiting scenario was more easily identified compared to the other three scenarios. Similar to the findings in Experiment 1, no relationship was found between participants' self-reported empathic abilities and performance in the scenario identification task when viewing videoclips of both neurotypical as well as ASD targets. Did the EQ scores of targets affect participants' ability to deduce what had happened to them? Similar to the findings in Experiments 1 and 3, no relationships were found between EQ scores of both ASD and neurotypical targets and participants' ability to correctly guess the scenario to which they were responding to.

Interpretation

It was found that people were able to successfully deduce the scenarios reacted to by neurotypical targets to a certain degree. Moreover, individuals were better at discriminating the scenarios when watching reactions of neurotypical compared to ASD targets with the exception of reactions to the Joke scenario which were equally identified. Hence despite there being a range of responses within the Joke scenario, targets with ASD responded in a manner comparable to the neurotypical targets providing valuable information for the reaction to be inferred. Nevertheless people's ability to better identify the remaining three scenarios in neurotypical targets as opposed to ASD targets perhaps implies that people with ASD may be largely less expressive compared to healthy controls (Yirmiya, Kasari, Sigman, & Mundy, 1989). On the other hand, it could also be that individuals with ASD respond in dissimilar ways from matched controls in some scenarios, making their reactions more challenging to interpret. This would be a possible justification for why participants were unable to deduce the reactions of targets with ASD in the Story and Compliments scenarios at all. Targets with ASD may have made indecipherable responses in the Story scenario due to its close association with empathic reactions, an area people with ASD are known to have difficulties in (Baron-Cohen & Wheelwright, 2004). Meanwhile, difficulties in experiencing self-conscious emotions (e.g. Heerey, Keltner, & Capps, 2003) may have impacted the way in which targets with ASD responded in the Compliments scenario.

Findings in the current experiment and Experiment 1 showed that participants' EQ scores were not associated with correct scenario identification when viewing videoclips of neurotypical and ASD targets. Similarly, targets' EQ scores were found not to influence participants' ability in correctly inferring the scenarios, supporting the findings in Experiments 1 and 3. This suggests that individual differences in self-reported empathic abilities and the resultant behavioural reactions do not influence people's capacity in inferring others' brief responses.

6.3 Practical & Theoretical Implications

6.3.1 Retrodictive Mentalising

People with and without ASD were generally able to infer from a range of brief samples of natural behaviour which scenario the target in question had experienced. Although people with ASD were less effective at deducing the scenarios as compared to neurotypical individuals, they did not demonstrate a complete deficit in inferring the mental states of others which has implications for Baron-Cohen's (1995) theory of mindblindness. Furthermore, the results also indicate that people employed successful strategies (i.e. retrodictive mentalising) in order to determine the antecedent of the behavioural responses (Gallese & Goldman, 1998). In essence, this implies that individuals were able to access an event in the social world through the window of another person's mind- as embodied by their behavioural reactions. The practical implications of this ability will be discussed a little later.

A potential criticism of this paradigm is that to correctly identify the scenarios, participants merely need to 'match' the reactions using behavioural rules; entirely circumventing the underlying mental state inference. Povinelli and Vonk (2003) termed this reasoning as "Povinelli's challenge". This challenge actually applies to all tests of mentalising - any pattern of responding in any test could theoretically be achieved through the application of a system of rules and principles without considering mental states themselves. It is certainly the case that we cannot rule out this explanation for the findings presented in this thesis. Nevertheless given the variety of behavioural reactions of targets to the same scenario, no simple matching strategy would appear to be appropriate. For example, a laughing response does not automatically correspond as a reaction to the Joke scenario as laughing responses were observed in the Story and Compliments scenarios as well. Moreover, Perner (2010) explained that even behavioural rules are not 'mind-blind behaviourism'; suggesting that it is essentially the product of the mind which is reflected in behavioural learning and rules. Finally, it is argued that even if the task is solved by matching according to behavioural rules, the poor performance of people with ASD point towards impairments in effectively applying these behavioural matching strategies, which would be just as worthy of investigation as impairments in mentalising.

Whilst most mentalising research has used the strategy of predicting mental states following a specific event or behaviour, the model employed in this thesis is novel in that it aimed to systematically examine the process in the reverse approach; as was proposed by Goldman and Sripada (2005) who called the process 'reverse simulation'. While it is known that mental states causally produce facial emotional expressions, the same process can be employed in a backwards direction for the purpose of reverse simulation. In the context of this model, it is proposed that the attributor first observes the behavioural responses (i.e. facial expressions) of a target and proceeds to mimic the observed expressions (automatically, extremely rapid and at a sub-threshold level). The attributor experiences the generated mental state and consequently classifies his or her own mental state. In accordance with a simulation heuristic, the attributor then categorises the target's mental state as the same as produced in him or herself. This model offers a reasonable account for the findings in this thesis. By this account, participants observe the behavioural reaction of the target, mimic his or her expression and as a consequence simulate the mental state of the target. Once the mental state is simulated, participants would then need to relate this feeling to a particular situation based on prior knowledge of the relationship between mental states and particular situational factors. According to the reverse simulation heuristic, if people are unable to simulate the above mentioned mental states, they would in consequence not be able to experience and subsequently recognise or interpret them.

Goldman and Sripada (2005) further elaborated that individuals who have impairments in producing, experiencing and expressing a mental state may also struggle in recognising the same mental state when it is seen in others. To reiterate, the basic premise in facial expression based mental state recognition is the requisite for facial mimicry of the observed expressions followed by subtle experiencing of the mimicked expression. This is then used to recognise the observed expressions in the other person. The difficulties in scenario identification displayed by people with ASD may be attributed to either step in the reverse simulation process i.e. the instantaneous mimicry or the experiencing or simulating of the mental state. It is also possible that people with ASD experience difficulty at the final stage of the process - matching simulated mental state with a particular situation. However, given that people with ASD were found to produce unusual (and difficult to interpret) responses themselves to the same events, it can be assumed that the performance of people with ASD is at least in part due to problems with either or both of the first two processes (mimicry and simulation). Contrastingly, Wright et al. (2008) reported that individuals with ASD compared to neurotypical controls were more likely to mimic observed facial expressions in an emotion expression recognition task, implying that they may be utilising specific simulation procedures as a compensatory strategy. However it does not come as a surprise that while these compensatory strategies may be effectively utilised in experimental conditions, they may not be as functional in an unstructured, fast-paced and naturalistic social context which often requires adaptable and context-appropriate reasoning ability.

On the other hand, Stel, van den Heuvel and Smeets (2008) reported that individuals with ASD showed impairments in automatic but not in intentional mimicry and that the deficits were present in both facial and behavioural mimicry. They also found that impairments in facial feedback mechanism played a role in emotion recognition difficulties displayed by people with ASD. This was evidenced by the fact that mimicry assisted neurotypical individuals to identify others' emotions however even instructing people with ASD to mimic did not improve their empathic abilities. Hence they concluded that mimicry and facial feedback play a vital role in understanding others' mental states as this facilitates perspective taking (Stel et al., 2008). As such it can be conjectured that mentalising deficits is partly influenced by mimicry and facial feedback processes. These impairments in mimicry and facial feedback processes have implications for the experience and expression of mental states in people with ASD as well as their understanding of others' mental states. The mirror neuron system can be considered as the potential biological instantiation of this process. Typical mirror neuron simulation is often 'automatic, unconscious, and pre-reflexive' and may function as a mechanism to detect mental states of others, hence possibly acting as a forerunner for or being a part of global mentalising abilities. Hence researchers have put forward that mirror neurons provide the foundation for one's ability simulate and understand the mental states of others, which is regarded as low-level mentalising.

The findings of this thesis have functional implications for the understanding and evaluation of mentalising ability in people with and without ASD. The paradigm used in this thesis differed from typically utilised measures of mentalising (i.e. false belief tasks, emotion recognition) with the development of a retrodictive mentalising task that attempts to tap into people’s ability to ascribe mental states in the real world. While false belief tasks often focus on the prediction of future behaviour, Milikan (2005) stated that in the social world people make sense of people’s behaviours only after the fact. Additionally, in real life people do not simply ascribe mental states from dynamic or static facial expression without there being a purpose and a valid social context. The findings of this thesis demonstrate that people are able to correctly identify the scenarios above chance level despite the heterogeneous and sometimes ambiguous behavioural reactions, with people with ASD performing less successfully compared to their typically developing counterparts. People with ASD showed impairments in correctly identifying the antecedent scenario implying that they had difficulties making sense of the targets’ responses.

Several factors were found to be associated with the poor ability of people with ASD to correctly distinguish the scenarios. It was found that neurotypical participants’ performance on the retrodictive mentalising task was independent of IQ ability, consistent with the findings of Rajkumar, Yovan, Raveendran, & Russell (2008) who concluded that mentalising skills exist as an independent cognitive domain not related to general intelligence. On the other hand, the ability of people with ASD to correctly identify the scenarios was related to cognitive ability; with higher IQ scores being associated with better scenario discrimination. Buitelaar, van der Wees, Swaab-Barneveld and van der Gaag (1999) conducted a study to examine the developmental components of theory of mind and emotion recognition ability in children with ASD and in a psychiatric control group individually matched for age and verbal IQ. Forty participants were administered a series of tasks including first and second order theory of mind tasks as well as a task of emotional expression recognition. They found that verbal memory, performance IQ and age were the best predictors of social cognitive ability. The findings reported in this thesis showed a positive correlation between full scale IQ scores and the ability to correctly identify the scenarios for individuals with ASD implying that heightened cognitive ability is associated with the facility to infer the mental states of others. On the other hand, a recent comprehensive meta-analysis of emotion recognition in ASD revealed that IQ level did not influence performance on emotion recognition tasks (Uljarevic & Hamilton, 2013).

It was also found that high scores on the Autism Spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) was related to a reduced capacity to correctly identify the scenarios. This implies that those who reported more autistic traits demonstrated poorer performance on the mentalising task. This is consistent with past research which has suggested that individuals with ASD have difficulties in tasks that require mentalising and the inferring of complex emotions (Golan, Baron-Cohen, Hill, & Golan, 2006). It can be construed that the social-communication difficulties characteristic of ASD have an impact on the ability to infer others' minds.

6.3.2 Emotional Expression

Findings from the work presented in this thesis revealed that people more easily identified the reactions to scenarios when viewing videoclips of neurotypical compared to targets with ASD. While targets with ASD displayed inferable reactions for the Joke and Waiting scenarios, their behavioural responses were undecipherable for the Compliments and Story scenarios, likely due to the possible self-conscious mental states associated with these reactions (e.g. Heerey, Keltner, & Capps, 2003). Therefore, it may be conjectured that there is a relationship between the mentalising impairments of targets with ASD and the quality of their behavioural responses to the four scenarios. Could it be that people with ASD have difficulty in distinguishing the scenarios targets were reacting to because they are impaired in putting themselves in others' shoes? Another explanation could be that though they may be able to engage in simulation, their responses may be qualitatively different from typically developing individuals. Both the abovementioned explanations should be taken into consideration. It is plausible to assume that people with ASD have the capacity to simulate, as they successfully inferred the scenarios to a certain degree. However, it could also be that they have difficulty in simulating certain reactions, perhaps ones which are unfamiliar or with a strong social component. On the other hand while their responses to some scenarios were identifiable, their un-interpretable behavioural responses in some scenarios indicate that their reactions were qualitatively different from neurotypical individuals.

The implications for retrodictive mentalising in the social world is manifold. In particular, it sheds light into the challenges individuals with ASD experience in day-to-day life. In line with the findings of this thesis, if people with ASD have problems in correctly inferring people's mental states to make sense of their behaviours, consequent challenges in social-communicative interactions are inevitable. In the same line of thought, if people are unable to infer the mental states of those with ASD, the same challenges will ensue. This underlines the two-way nature of normal social communication and the social-communicative deficits experienced by those with ASD. Implications for treatment strategies for people with ASD would involve not only improving understanding of others' mental states as embodied in their behaviour but also the understanding and appropriate expression of one's own mental state. The findings in this thesis highlight the subtle mentalising deficits that may be present in real-world settings in those with ASD.

Imagine attempting to understand and interact with others short of knowing their beliefs, feelings or thoughts. Though it is a given that we may not know *exactly* the content of another person's mind, the ability to infer others' mental states is an imperative skill set for successful social interactions. The example scenario described in Chapter 1 is now reconsidered in a different context. An employee is seen walking out of her superior's office looking slightly disgruntled. It would be fair to assume that this person may not be feeling particularly happy perhaps due to an unpleasant conversation with her superior. A person with ASD on the other hand, may not pick up on the employee's subtle facial expressions and may consequently fail to infer that an upsetting event may have taken place during the meeting. Without this knowledge, the person with ASD may proceed to interact with the employee as if nothing had happened; hence not showing concern or empathising with her situation. People with ASD would most likely behave in a different manner compared to typically developing individuals in a situation like this as a result of not being privy to the mental states of others. This along with multiple other instances of social situations wherein others' mental states are not taken into consideration would significantly impact on the quality of social relationships that people with ASD have. It is often taken for granted the extent to which typically developing people use others' thoughts and feelings to facilitate successful socio-communicative interactions. People with ASD often present with subtle mentalising deficits in real life due to the many social norms to adhere by as well as various situational and social contexts. Compensatory strategies that may have been successfully utilised in experimental conditions may not be supported in real-world settings due to the dynamic, spontaneous and multifaceted nature of social interactions. Therefore it is possible that the retrodictive mentalising difficulties displayed by individuals with ASD can account for some of the social impediments in day-to-day functioning- their difficulty in gauging the mental states of others would manifest in their subsequent behaviours which may not be conducive for effective social interactions.

6.3.3 Gaze Behaviour

A large sum of research has shown that individuals with ASD have face processing impairments (e.g. Pellicano, Jeffery, Burr, & Rhodes, 2007). Studies utilising eye tracking techniques have in general consistently demonstrated that both adults and children with ASD show reduced attention to the facial region compared to healthy controls (e.g. Falck-Ytter, Fernell, Gillberg, & von Hofsten, 2010). However the same cannot be said for findings of visual attention to specific parts of the facial region, namely eye or mouth. While some studies have reported that individuals with ASD show reduced gaze time at the eye region (e.g. Hernandez et al., 2009), others have found reduced fixation at the mouth region (e.g. Chawarska, Macari, & Shic, 2012). On the other hand, there have also been studies which have found no differences in visual fixation patterns to specific facial regions between individuals with and without ASD (Bar-Haim, Shulman, Lamy, & Reuveni, 2006; Freeth, Ropar, Mitchell, Chapman, & Loher, 2011; Rutherford & Towns, 2008; Wagner, Hirsch, Vogel-Farley, Redcay, & Nelson, 2013).

The studies in this thesis showed that individuals (both neurotypical and ASD) had a preference for the mouth over the eye region, in support of Kirchner, Hatri, Heekeren and Dziobek (2010) who found increased fixation time in the mouth region as compared to the eye region in emotional recognition conditions (i.e. conditions high in social salience). Of great importance is that no differences were found between visual attention to the eye or mouth between neurotypical and individuals with ASD. This finding was contrary to studies (e.g. Corden, Chilvers, & Skuse, 2008; Spezio, Adolphs, Hurley, & Piven, 2007) which have shown that individuals with ASD compared to neurotypical controls did not utilise information from the eye region of the face and instead tended to focus on information from the mouth region. As such, the findings indicate that the poor performance of individuals with ASD in identifying the scenarios is not merely due to reduced looking at the eye region. Instead it appears that individuals with and without ASD focus their visual attention on face regions which are most informative for deducing targets' behavioural reactions. In spite of this, individuals with ASD are still inferior compared to neurotypical individuals at making correct judgments about the scenarios to which targets responded.

A number of recent studies are consistent with these findings. McPartland, Webb, Keehn, & Dawson (2011) employed eye tracking to investigate the gaze behaviours to objects and faces in adolescents with ASD and matched typically developing controls. Participants viewed images of upright human faces, inverted human faces, monkey faces, two-dimensional geometric designs as well as three-dimensional curvilinear objects. The results indicated that while individuals with ASD obtained lower scores on the face recognition task compared to controls, both groups demonstrated comparable patterns of gaze attention i.e. increased focus on the upper region compared to the lower region of the face. These findings refute the idea that people with ASD do not focus on the eye region of the face. Nevertheless, individuals with ASD showed impairments in face processing compared to their neurotypical counterparts i.e. results which are comparable to the present findings.

Sawyer, Williamson and Young (2012) examined whether the differences in visual attention to faces displayed by those with ASD can account for their impairments in emotion recognition from facial expressions. The study consisted of three emotion recognition conditions- full face, mouth only and eyes only. Their findings revealed that there were no differences in the way people with and without ASD viewed faces. Furthermore, there was no evidence of gaze avoidance compared to neurotypical controls. Nevertheless, individuals with ASD were less skilled at accurately identifying the emotions in all conditions compared to typically developing comparison participants.

Blais, Roy, Fiset, Arguin, and Gosselin (2012) conducted an innovative study using the Bubbles technique to evaluate the most informative facial cue when discriminating between facial expressions (eight static and eight dynamic stimuli) consisting of six basic emotions, pain and a neutral expression. Their findings revealed that the mouth was in fact the most important facial cue when distinguishing both static as well as dynamic stimuli. In addition, participants compared to the ideal observer displayed underuse of the eye area. Blais et al. (2012) proposed that people’s utilisation of the mouth region may be related to its function of having the most discriminative motions across facial expressions. They further explained that this strategy may have evolved over time due to the dynamic nature of information conveyed from the mouth region and its relevance in an ecological context. Another explanation for the inclination towards the mouth region is the preference for audiovisual synchrony (Jones et al., 2008); that is the integration of dynamic visual stimuli and auditory signals to form a strong perceptual foundation.

A majority of research has emphasised the importance of the eye region in recognising certain mental states (e.g. Baron-Cohen, Wheelwright, Jolliffe, & Therese, 1997; Smith, Cottrell, Gosselin, & Schyns, 2005). And as a key characteristic of ASD is the impaired use of eye contact coupled with social-communication difficulties, it is not surprising that the visual attention patterns and mental state recognition of people with ASD have been widely studied. In line with this, it has been proposed that the poor performance on face recognition tasks (e.g. Jones, Carr, & Klin, 2008; Klin, Jones, Schultz, Volkmar, & Cohen, 2002) of children with ASD may be related to their propensity to avoid eye contact as the eyes are often acknowledged as a crucial component of face processing. The findings in this thesis do not undermine the possibility that the eyes play an important part in the development of social communication skills in children who are typically developing; neither do they suggest that there are no abnormalities in eye gaze behaviour in those with ASD. However, these and the studies reviewed above suggest that group differences in eye gaze behaviour may be limited to certain circumstances and may be dependent on the specific task employed. This brings rise to the question- why is it that individuals with ASD who display similar visual attention to the eye region as typically developing individuals still struggle with these tasks? The answer must surely lie within not merely where one’s gaze is directed, but rather how the information taken in is actually used to assist in mental state identification. If it is the case that individuals with ASD have impairments in their ability to mimic others' facial expressions and/or to simulate their mental states as described in the sections above, then it is quite possible that attending to the "right" parts of the face is not sufficient to overcome these difficulties.

6.3.4 *Empathy*

Empathy has been described as the “capacity to understand others and experience their feelings in relation to oneself” (Decety & Jackson, 2004, p.71). Both the affective and cognitive components of empathy play important roles in successful development of empathic abilities which in turn aid in effective interactions in the social world. While some researchers have emphasised the discrepancies between the two components of empathy, Baron-Cohen and Wheelwright (2004) assert the distinction is theoretical and that these two elements often coincide in reality. They also stated that empathic skills are vital in the development of high-order social functioning as well as the maintenance of long-term social engagements (Baron-Cohen & Wheelwright, 2004). Ickes (1993) put forward that being perceptive of others’ emotional states and appropriately responding to them are crucial constituents of empathic behaviour. In recognition of this, the relationship between self-reported trait empathic ability (as measured by the EQ) and retrodictive mentalising ability (as measured by performance in scenario identification) was investigated.

Two of the studies in this thesis found that people’s self-reported empathic ability was not associated with correct scenario identification when viewing videoclips of neurotypical targets. This finding was surprising given the literature which has shown a positive correlation between self-reported affective empathy and identification of facial affect (e.g. Gery, Miljkovitch, Berthoz, & Soussignan, 2009; Martin, Berry, Dobranski, Horne, & Dodgson, 1996). A recent study by Besel and Yuille (2010) also found that scores on the EQ were positively related to accuracy during brief exposure in an emotion recognition task operationalised through Ekman’s Pictures of Facial Affect. Nonetheless it is important to note that while the EQ was developed as a global measure of empathy, studies have shown that it strongly highlights cognitive empathy and social knowledge as compared to aspects of affective empathy (Lawrence, Shaw, Baker, Baron-Cohen, & David, 2004; Muncer & Ling, 2006). If empathising is not a unitary construct this might explain the lack of relationship with task performance in this thesis.

It was however, revealed that people's empathic ability was in fact positively associated with scenario identification when viewing videoclips of targets with ASD only, lending support to previous studies which have shown positive relationships between empathic ability and mental state recognition (e.g. Gery et al., 2009). This finding calls for an explanation and might possibly be accounted for by the generalised difficulty in interpreting the reactions portrayed specifically by targets with ASD and not the neurotypical controls. Perhaps higher trait empathic abilities were required to correctly decipher the obscure reactions of targets with ASD.

In addition to investigating the relationship of performance to the participants' EQ scores, the relationship between performance on the retrodictive mentalising task and the EQ scores of targets was also examined. This was based on the assumption that targets who have higher EQ would have empathised more strongly with the researcher and thus her behaviour might have induced a greater degree of expressivity from them. Gross and John (1997) stated that if targets are highly expressive and respond suitably according to their experienced affect, it may be easier for people to distinguish what they experienced as more relevant information is available for evaluation. Overall, the findings in this thesis were ambiguous regarding the relationship between targets' EQ scores and people's ability in identifying the scenarios. There were relationships for some of the scenarios and not others, but these were not found consistently across experiments (although the small sample sizes render the findings inconclusive). It may be that relationships do hold for some scenarios but further research is needed.

Zaki, Bolger and Ochsner (2008) conducted an elegant study which provides an explanation of empathic accuracy ability with both the perceiver and target in mind. Their study consisted of two phases; target phase and perceiver phase. In the target phase, 14 participants completed the Berkeley Expressivity Questionnaire (BEQ; Gross & John, 1995) which measured individuals' insight into how much of their affective experience is observable to others. They were then filmed while discussing four positive and four negative personal events. Participants then watched their own films and gave ratings on a scale ranking their feelings from negative to positive. In the perceiver phase of the study, 33 fresh participants completed the Balanced Emotional Empathy Scale (BEES; Mehrabian & Epstein, 1972) which measured individuals' self-reported affective empathy. Participants subsequently watched the films of the targets and rated how negative or positive they perceived the target was feeling. Zaki et al. (2008) defined their measure of empathic accuracy as the correlation between the targets' ratings of their own feelings and perceivers' ratings of what they believed the targets were feeling. The findings revealed that perceivers' trait affective empathy was not associated with empathic accuracy unless targets' emotion expressivity was taken into consideration. As a result, perceivers' self-reported empathic level predicted accuracy only for targets who were expressive. This suggests that one's self-reported empathic ability can predict their subsequent empathic accuracy, but only when targets are sufficiently expressive. Zaki et al. (2008) also suggest that targets who showed low levels of expressiveness do provide useful affective indicators, however empathic perceivers may less effectively interpret their emotions as they may be more acclimatised to more expressive stimuli. To explain further, it is possible that the expressions of targets who displayed low expressivity were not as temporally dynamic as high expressivity targets; as such perceivers may interpret subtle changes in affect exhibited only by expressive targets.

While the current thesis only employed the EQ to measure levels of empathic ability, perhaps utilising a measure of self-expression such as the

BEQ (Gross & John, 1995) would have rendered supplementary yet pertinent information in order to examine the relationship between performance in the mentalising task, self-reported empathic ability as well as emotional expressiveness. Moreover, Zaki et al.'s (2008) findings highlighted the importance of taking into account targets' expressivity as it has an influence on empathy related behaviours. In addition, while it is understood that there may be an overlap between cognitive and affective empathy, the studies in the present thesis aimed to tap into mentalising ability which has been closely associated with cognitive empathy. Baron-Cohen & Wheelwright (2004) put forward that while they may be related, impairments in cognitive empathy may coincide with advanced abilities in affective empathy. As such it is a possibility that these individual measures may relate to the scenario identification task in varying ways.

The value of measures of empathy in predicting actual empathic behaviour has been called into question, as evidenced by the poor and sometimes non-existent relationship between measures of empathic ability and performance on empathy related tasks. Nonetheless, the findings from the studies in this thesis indicate that there is indeed a connection between empathic ability, emotion expressivity and retrodictive mentalising ability, although not consistently so.

6.4 Limitations

There are several limitations to the studies in this thesis which must be acknowledged. A forced-choice response system was used for the primary task of accurate scenario identification. The use of forced-choice formats have been criticised in emotion recognition studies whereby it may be the case that relative judgment occurs in which people tend to select the answer that seems most likely (Russell, 1993). In three different trials of his study, a majority of participants identified the 'anger' expression as 'contempt', 'disgust' and 'frustration' via forced-choice format options. Then when shown the ‘anger’ expression in a forced-choice format with very closely related options such ‘anger’ and ‘frustration’, only 12.5% of participants on average correctly selected ‘anger’ for stimuli depicting angry expressions. Hence Russell (1993) contended that forced-choice formats can yield consensus on the wrong answers (as seen in the first three trials of the study). And despite ‘anger’ being the accurate response, forced choice may fail to concede consensus on the correct answer. However recent findings have contested the notion that forced-choice formats do not effectively reveal performance in emotion recognition tasks (Limbrecht-Ecklundt et al., 2013). In this thesis, the problem of naming mental states from a list of options is surpassed as individuals are required to name the scenarios which they think took place prior to targets’ presented behavioural responses. Nonetheless, it might be interesting to conduct a similar study using a free-response format. While one might not expect participants to accurately guess exactly what had happened, it is possible that they would provide responses with a degree of similarity to the actual event.

The studies involving participants with ASD were all males. It is not surprising however that males make up the large majority of participants and are hence often over represented in the ASD literature as they are five times more likely to have ASD compared to females (Center for Disease Control and Prevention, 2012). Nonetheless, the performance of female participants with ASD should be considered in future; Lai et al. (2011) found that females compared to males with ASD presented with higher level of autistic traits on the AQ. However, they had fewer socio-communication difficulties as measured by the ADOS compared to males. As the manifestation of the symptomatic characteristics of ASD may differ between males and females, it would be appropriate to investigate if females with ASD present with similar gaze patterns and performance in the present retrodictive mentalising task.

The studies in this thesis utilized self-report measures of empathy. However one’s own reporting is confounded by social desirability bias as well as minimal insight into judging own empathic ability. Hence second person assessment of empathy would be advantageous in order to strengthen the findings (Bartels, Boomsma, Hudziak, van Beijsterveldt, & van den Oord, 2007). Furthermore, it may have been advantageous to use other standardised mentalising tasks (i.e., Strange Stories Test & Faux-Pas Test) to further corroborate the findings of this newly developed retrodictive mentalising task. While it is proposed that the current retrodictive mentalising paradigm is potentially a more compelling measure of mentalising ability, it would be interesting nonetheless to compare and contrast the findings. If differences in findings are found, they may be attributed to the inherent nature of the current task which utilises naturalistic video stimuli which most closely represents real-world interactions hence tapping into more subtle mentalising deficits compared to standard tasks of mentalising.

It may be contended that acculturation effects may be present in the reported studies due the varying cultural backgrounds of both targets and participants. Jack, Blais, Scheepers, Schyns, and Caldara (2009) reported cultural differences in the way Easterners and Westerners recognise emotional expressions. Furthermore, Masuda et al. (2008) suggested that emotion recognition is impacted by cultural differences in attentional patterns to contextual components; whereby Japanese participants' ratings were influenced by surrounding people's emotions whereas Westerners' ratings were not. This points to the differences in the way people from individualistic and collectivistic cultures attend to emotions and their contextual information. Nevertheless in this thesis, direct recognition and labelling of emotions were not employed. As such in order to preserve the real-world component of the studies, it was considered reasonable to include participants and targets (portraying varying behavioural reactions) of different cultural backgrounds to closely approximate real life encounters. Furthermore, in the studies which compared groups of participants with and without ASD, the groups were matched in ethnicity so this could not have acted as a confound or explain any group differences. Nonetheless, future research should attempt to investigate the cross-cultural effects of the ability of people with and without ASD to infer mental states.

In addition, it may be beneficial to broaden the scope of future studies by not just examining fixations to eye and mouth regions but also other areas of interest such as the nose. This is of particular interest in a cross-cultural context as studies have shown that East Asians tend to fixate on the central area of the face (i.e. nose) while Western Caucasians displayed triangular looking patterns (scattered between eye and mouth) during facial recognition tasks (Blais, Jack, Scheepers, Fiset, & Caldara, 2008). In this thesis the studies follow typical ASD research conventions whereby gaze behaviours towards eye and mouth regions of the face were the focus of investigation (e.g. Hernandez et al., 2009; Klin, Jones, Schultz, Volkmar, & Cohen, 2002; Rutherford & Towns, 2008) but it is possible that considering gaze at the nose would have furnished us with further useful information.

The findings of the studies presented in this thesis suggest that people with and without ASD looked more at the mouth as compared to the eye region. This is consistent with several other recent studies which have supported the importance of the mouth when dynamic stimuli are used. For instance, Vatikiotis-Bateson, Eigsti, Yano and Munhall (1998) investigated people's eye movements during an audio-visual perception task. Participants (native English and native Japanese speakers) were shown conversational monologues of different image sizes and varying levels of acoustic masking noise. It was found that irrespective of image size, all participants gazed more at the mouth as masking noise levels increased. In contrast, Võ, Smith, Mital, and Henderson (2012) reported that people's fixations to the mouth increased when the facial stimuli was speaking; however, when the speech component was removed, fixation time to the face and specifically the mouth region decreased significantly. In this thesis, auditory information was omitted from the videoclips, yet the dynamic motions of the mouth persisted. This suggests that there are individual differences in the way in which people prioritise gaze towards critical regions to support a functional purpose and that the importance of information from the mouth when understanding others may have been underestimated by previous studies using static stimuli.

The videoclips of target behavioural reactions were captured using naturalistic methods. Hence the responses displayed were targets‘ spontaneous and genuine responses to the scenarios. On the other hand, when the videoclips were displayed in the main experiment, while the reactions itself were natural responses, the videoclips comprised mainly faces and upper-bodies with no distracting information such as objects, landscapes which could have captured one‘s attention. Furthermore, it is acknowledged that despite all efforts to create stimuli which are as naturalistic and ecologically valid as possible, the stimuli had to be presented in a controlled, experimental environment on a computer monitor. This in turn does not fully correspond and translate to the features of real-world social relations.

6.5 Directions for Future Research

There are a number of possibilities for future research in the current area of study. The findings in this thesis revealed that individuals with ASD have the capacity to infer others’ mental states to a certain extent. It was also found that people with ASD are capable of portraying intelligible behavioural reactions to certain scenarios. It would be interesting to examine other factors that may be related to one’s abilities in these domains; both in identifying mental states as well as the self-expression of mental states. For instance; does one’s level of adaptive behaviour functioning have an impact on their capacity to understand and express mental states? What about the performance of individuals with ASD who had exposure to early intervention and/or social skills training as compared to those who have not? And does opportunity of peer interaction have an impact on this ability? Perhaps comparing individuals educated in standard schooling system vs. home-schooling environment would be a way at answering some of these questions. Another factor to consider would be the impact of siblings in a family. These variables may or may not influence one's capacity to mentalise; however if such a connection exists, they can be utilised as indicators to guide appropriate intervention.

While the current task successfully utilised natural stimuli presented through film, the task of inferring one's mental state in real world settings would involve the integration of other complex facets of social interaction which are known areas of difficulty for people with ASD such as prosody, language, body language as well as context (e.g. Paul, Augustyn, Klin, & Volkmar, 2005). Therefore, investigations using real-time processing and examining physiological responses would provide greater insight into the ability of people to infer others' mental states. Furthermore, in accordance with the model used in the present thesis, new scenarios could be created to further investigate people's ability to mentalise in various social situations. For instance, to examine the capacity of people with and without ASD to experience vicarious embarrassment, incorporated into this model of retrodictive mentalising. It has been shown that the empathic process is an essential prerequisite to experience vicarious embarrassment (Krach et al., 2011). Moreover, Paulus, Kamp-Becker and Krach (2013) reported that people with ASD showed deficits in reporting of vicarious embarrassment in social situations as it required the understanding of another person's mental state.

The participants in the studies reported in this thesis had a wide range of cognitive abilities, although all were within the normal range of intellectual functioning. As a consequence the performance of individuals with lower cognitive abilities is unknown in this task. It was previously discussed that while a large number of children with ASD are unable to pass complex mentalising tasks, high-functioning adults with ASD on the other hand often show success in such tasks. Thus it has been suggested that the mentalising impairments of adults with ASD are more subtle as compared to children with ASD. Hence, it would be of interest to administer this task to children with ASD. In the same line of thought, research has also shown that mentalising abilities may decline with age (e.g. Slessor, Phillips, & Bull, 2007); therefore the abilities of older adults in this naturalistic retrodictive mentalising should also be investigated. It will also be interesting to conduct these studies with other populations known to have deficits in mentalising, such as individuals with schizophrenia or borderline personality disorder.

Future research should incorporate neuroimaging studies to complement the present behavioural paradigm to better understand the neural networks which facilitates retrodictive mentalising. While it is known that social and situational circumstances play a vital role in everyday mentalising, a clearer understanding at a neuroscientific level along with the incorporation of knowledge from corresponding domains such as low-level mentalising, mirroring, simulation, perspective-taking, emotion contagion and empathy will provide a more complete picture of people's capacity to infer others' mental states and make sense of behaviour.

6.6 Conclusions

In summary, people with and without ASD were able to infer events that occurred to target participants by viewing brief samples of behavioural reactions. Despite focusing on the same regions of the face, individuals with ASD showed deficits in deducing the scenarios compared to typically developing individuals. People varied their visual attention according to the scenario experienced by the targets in the videoclips suggesting that people tended to change their viewing strategies towards the most informative areas based on targets' behavioural cues. Participant and target self-reported empathic ability was associated with participants' performance in correct scenario identification to a certain degree, however not consistently so. Findings also showed that individuals with ASD expressed inferable behavioural reactions to some scenarios only.

The retrodictive mentalising task presented in this thesis objectively examined people's ability to infer others' mental states using naturalistic video stimuli. While other studies have increased the difficulty of such tasks by ambiguating the facial expressions (for example through the morphing of stimuli, Law Smith, Montagne, Perrett, Gill, & Gallagher, 2010); the present task consisted of stimuli which were filmed in a naturalistic and genuine social interaction, representative of encounters in the real world. As subtle mentalising impairments of people with ASD seem to be most evident during dynamic, unstructured and naturalistic tasks (Pelphrey, Morris, McCarthy, & LaBar, 2007), the mentalising task employed in this thesis accounted for the abovementioned components and further provides insight into the retrodictive abilities of people with and without ASD in determining what they believe happened to someone simply by watching their brief behavioural reactions. The advantage of this novel paradigm is its simplistic yet efficient way of learning about one's deduction of others' mental states in a given situational context, without directly labelling a mental state, which has long been an issue with mentalising research.

While there is no explicit mention of mental state identification, it is implied that one will utilise retrodictive mentalising skills in order to successfully discern one situation from the other. The ability of individuals with ASD to pass certain advanced tasks of mentalising demonstrates that their capacity to infer the minds of others' should not be undervalued. Nonetheless this does not go so far as to imply that their ability to successfully infer others' minds in contrived experimental conditions would be reflected in appropriate social behaviours and interpersonal relationships in the real world. As such, Astington (2003) put forward that while people with ASD may demonstrate some mentalising skills, they may not be sufficient for effective social functioning in day-to-day life. Additional studies are needed to shed more light on this issue. Furthermore, future studies of mental state understanding of individuals with ASD should bear in mind that time spent looking at the critical regions of the face may not necessarily reflect the processing of relevant information. As evidenced in the work presented in this thesis; while people with and without ASD showed similar patterns of visual attention, people with ASD were less successful than neurotypicals in correctly identifying the scenarios. Nonetheless, further explication in regards to the psychological and neuroanatomical factors of the often reported socio-communicative gaze irregularities in ASD may assist in more sensitive early diagnostic evaluations and subsequent intervention.

The facility to make such inferences about others may be functional not only because it permits us to make sense of others' behaviour, but perhaps even enables us to benefit indirectly from the experiences of others, and hence can be used as an effective tool for learning about events in the world. The ability to engage in retrodictive mentalising is an imperative skill required in the social world today as our daily lives often entail observing people's reactions and behaviours and further attempting to determine what motivated those responses. The findings from the work presented in this thesis have highlighted the significance of investigating subtle naturalistic expressions and social cues as well as the ability to "put oneself in another person's shoes" as vital for successful social communication in daily living. Further studies addressing the gaps in knowledge in the literature is necessary in order to obtain critical insights into the causes of deficient social cognition in people with ASD and the association between neurological, developmental and socio-communicative information processing. Moreover, a greater understanding of the profound real-world challenges faced by people with ASD in everyday social situations and interactions will steer the way for improved functional intervention and support.

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Appendix A

Empathy Quotient (EQ)

1. I can easily tell if someone else wants to enter a conversation.	strongly agree	slightly agree	slightly disagree	strongly disagree
2. I find it difficult to explain to others things that I understand easily, when they don't understand it first time.	strongly agree	slightly agree	slightly disagree	strongly disagree
3. I really enjoy caring for other people.	strongly agree	slightly agree	slightly disagree	strongly disagree
4. I find it hard to know what to do in a social situation.	strongly agree	slightly agree	slightly disagree	strongly disagree
5. People often tell me that I went too far in driving my point home in a discussion.	strongly agree	slightly agree	slightly disagree	strongly disagree
6. It doesn't bother me too much if I am late meeting a friend.	strongly agree	slightly agree	slightly disagree	strongly disagree
7. Friendships and relationships are just too difficult, so I tend not to bother with them.	strongly agree	slightly agree	slightly disagree	strongly disagree
8. I often find it difficult to judge if something is rude or polite.	strongly agree	slightly agree	slightly disagree	strongly disagree
9. In a conversation, I tend to focus on my own thoughts rather than on what my listener might be thinking.	strongly agree	slightly agree	slightly disagree	strongly disagree
10. When I was a child, I enjoyed cutting up worms to see what would happen.	strongly agree	slightly agree	slightly disagree	strongly disagree
11. I can pick up quickly if someone says one thing but means another.	strongly agree	slightly agree	slightly disagree	strongly disagree
12. It is hard for me to see why some things upset people so much.	strongly agree	slightly agree	slightly disagree	strongly disagree

13. I find it easy to put myself in somebody else's shoes.	strongly agree	slightly agree	slightly disagree	strongly disagree
14. I am good at predicting how someone will feel.	strongly agree	slightly agree	slightly disagree	strongly disagree
15. I am quick to spot when someone in a group is feeling awkward or uncomfortable.	strongly agree	slightly agree	slightly disagree	strongly disagree
16. If I say something that someone else is offended by, I think that that's their problem, not mine.	strongly agree	slightly agree	slightly disagree	strongly disagree
17. If anyone asked me if I liked their haircut, I would reply truthfully, even if I didn't like it.	strongly agree	slightly agree	slightly disagree	strongly disagree
18. I can't always see why someone should have felt offended by a remark.	strongly agree	slightly agree	slightly disagree	strongly disagree
19. Seeing people cry doesn't really upset me.	strongly agree	slightly agree	slightly disagree	strongly disagree
20. I am very blunt, which some people take to be rudeness, even though this is unintentional.	strongly agree	slightly agree	slightly disagree	strongly disagree
21. I don’t tend to find social situations confusing.	strongly agree	slightly agree	slightly disagree	strongly disagree
22. Other people tell me I am good at understanding how they are feeling and what they are thinking.	strongly agree	slightly agree	slightly disagree	strongly disagree
23. When I talk to people, I tend to talk about their experiences rather than my own.	strongly agree	slightly agree	slightly disagree	strongly disagree
24. It upsets me to see an animal in pain.	strongly agree	slightly agree	slightly disagree	strongly disagree
25. I am able to make decisions without being influenced by people's feelings.	strongly agree	slightly agree	slightly disagree	strongly disagree
26. I can easily tell if someone else is interested or bored with what I am saying.	strongly agree	slightly agree	slightly disagree	strongly disagree

27. I get upset if I see people suffering on news programmes.	strongly agree	slightly agree	slightly disagree	strongly disagree
28. Friends usually talk to me about their problems as they say that I am very understanding.	strongly agree	slightly agree	slightly disagree	strongly disagree
29. I can sense if I am intruding, even if the other person doesn't tell me.	strongly agree	slightly agree	slightly disagree	strongly disagree
30. People sometimes tell me that I have gone too far with teasing.	strongly agree	slightly agree	slightly disagree	strongly disagree
31. Other people often say that I am insensitive, though I don’t always see why.	strongly agree	slightly agree	slightly disagree	strongly disagree
32. If I see a stranger in a group, I think that it is up to them to make an effort to join in.	strongly agree	slightly agree	slightly disagree	strongly disagree
33. I usually stay emotionally detached when watching a film.	strongly agree	slightly agree	slightly disagree	strongly disagree
34. I can tune into how someone else feels rapidly and intuitively.	strongly agree	slightly agree	slightly disagree	strongly disagree
35. I can easily work out what another person might want to talk about.	strongly agree	slightly agree	slightly disagree	strongly disagree
36. I can tell if someone is masking their true emotion.	strongly agree	slightly agree	slightly disagree	strongly disagree
37. I don't consciously work out the rules of social situations.	strongly agree	slightly agree	slightly disagree	strongly disagree
38. I am good at predicting what someone will do.	strongly agree	slightly agree	slightly disagree	strongly disagree
39. I tend to get emotionally involved with a friend's problems.	strongly agree	slightly agree	slightly disagree	strongly disagree
40. I can usually appreciate the other person's viewpoint, even if I don't agree with it.	strongly agree	slightly agree	slightly disagree	strongly disagree

Appendix B

Autism Spectrum Quotient (AQ)

1. I prefer to do things with others rather than on my own.	definitely agree	slightly agree	slightly disagree	definitely disagree
2. I prefer to do things the same way over and over again.	definitely agree	slightly agree	slightly disagree	definitely disagree
3. If I try to imagine something, I find it very easy to create a picture in my mind.	definitely agree	slightly agree	slightly disagree	definitely disagree
4. I frequently get so strongly absorbed in one thing that I lose sight of other things.	definitely agree	slightly agree	slightly disagree	definitely disagree
5. I often notice small sounds when others do not.	definitely agree	slightly agree	slightly disagree	definitely disagree
6. I usually notice car number plates or similar strings of information.	definitely agree	slightly agree	slightly disagree	definitely disagree
7. Other people frequently tell me that what I've said is impolite, even though I think it is polite.	definitely agree	slightly agree	slightly disagree	definitely disagree
8. When I'm reading a story, I can easily imagine what the characters might look like.	definitely agree	slightly agree	slightly disagree	definitely disagree
9. I am fascinated by dates.	definitely agree	slightly agree	slightly disagree	definitely disagree
10. In a social group, I can easily keep track of several different people's conversations.	definitely agree	slightly agree	slightly disagree	definitely disagree
11. I find social situations easy.	definitely agree	slightly agree	slightly disagree	definitely disagree
12. I tend to notice details that others do not.	definitely agree	slightly agree	slightly disagree	definitely disagree
13. I would rather go to a library than a party.	definitely agree	slightly agree	slightly disagree	definitely disagree
14. I find making up stories easy.	definitely agree	slightly agree	slightly disagree	definitely disagree

15.	I find myself drawn more strongly to people than to things.	definitely agree	slightly agree	slightly disagree	definitely disagree
16.	I tend to have very strong interests which I get upset about if I can't pursue.	definitely agree	slightly agree	slightly disagree	definitely disagree
17.	I enjoy social chit-chat.	definitely agree	slightly agree	slightly disagree	definitely disagree
18.	When I talk, it isn't always easy for others to get a word in edgeways.	definitely agree	slightly agree	slightly disagree	definitely disagree
19.	I am fascinated by numbers.	definitely agree	slightly agree	slightly disagree	definitely disagree
20.	When I'm reading a story, I find it difficult to work out the characters' intentions.	definitely agree	slightly agree	slightly disagree	definitely disagree
21.	I don't particularly enjoy reading fiction.	definitely agree	slightly agree	slightly disagree	definitely disagree
22.	I find it hard to make new friends.	definitely agree	slightly agree	slightly disagree	definitely disagree
23.	I notice patterns in things all the time.	definitely agree	slightly agree	slightly disagree	definitely disagree
24.	I would rather go to the theatre than a museum.	definitely agree	slightly agree	slightly disagree	definitely disagree
25.	It does not upset me if my daily routine is disturbed.	definitely agree	slightly agree	slightly disagree	definitely disagree
26.	I frequently find that I don't know how to keep a conversation going.	definitely agree	slightly agree	slightly disagree	definitely disagree
27.	I find it easy to "read between the lines" when someone is talking to me.	definitely agree	slightly agree	slightly disagree	definitely disagree
28.	I usually concentrate more on the whole picture, rather than the small details.	definitely agree	slightly agree	slightly disagree	definitely disagree
29.	I am not very good at remembering phone numbers.	definitely agree	slightly agree	slightly disagree	definitely disagree
30.	I don't usually notice small changes in a situation, or a person's appearance.	definitely agree	slightly agree	slightly disagree	definitely disagree
31.	I know how to tell if someone listening to me is getting bored.	definitely agree	slightly agree	slightly disagree	definitely disagree

32. I find it easy to do more than one thing at once.	definitely agree	slightly agree	slightly disagree	definitely disagree
33. When I talk on the phone, I'm not sure when it's my turn to speak.	definitely agree	slightly agree	slightly disagree	definitely disagree
34. I enjoy doing things spontaneously.	definitely agree	slightly agree	slightly disagree	definitely disagree
35. I am often the last to understand the point of a joke.	definitely agree	slightly agree	slightly disagree	definitely disagree
36. I find it easy to work out what someone is thinking or feeling just by looking at their face.	definitely agree	slightly agree	slightly disagree	definitely disagree
37. If there is an interruption, I can switch back to what I was doing very quickly.	definitely agree	slightly agree	slightly disagree	definitely disagree
38. I am good at social chit-chat.	definitely agree	slightly agree	slightly disagree	definitely disagree
39. People often tell me that I keep going on and on about the same thing.	definitely agree	slightly agree	slightly disagree	definitely disagree
40. When I was young, I used to enjoy playing games involving pretending with other children.	definitely agree	slightly agree	slightly disagree	definitely disagree
41. I like to collect information about categories of things (e.g. types of car, types of bird, types of train, types of plant, etc.).	definitely agree	slightly agree	slightly disagree	definitely disagree
42. I find it difficult to imagine what it would be like to be someone else.	definitely agree	slightly agree	slightly disagree	definitely disagree
43. I like to plan any activities I participate in carefully.	definitely agree	slightly agree	slightly disagree	definitely disagree
44. I enjoy social occasions.	definitely agree	slightly agree	slightly disagree	definitely disagree
45. I find it difficult to work out people's intentions.	definitely agree	slightly agree	slightly disagree	definitely disagree
46. New situations make me anxious.	definitely agree	slightly agree	slightly disagree	definitely disagree
47. I enjoy meeting new people	definitely agree	slightly agree	slightly disagree	definitely disagree

48. I am a good diplomat	definitely agree	slightly agree	slightly disagree	definitely disagree
49. I am not very good at remembering people's date of birth.	definitely agree	slightly agree	slightly disagree	definitely disagree
50. I find it very easy to play games with children that involve pretending.	definitely agree	slightly agree	slightly disagree	definitely disagree