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Other-regarding preferences and the decision behaviour of autistic people in the ultimatum game

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Thesis submitted to City, University of London for the degree of Doctor of Philosophy

Department of Psychology

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GLOSARY

Some terms that will be used throughout this thesis will carry a specific meaning. For ease of reference these terms and their definitions are listed here.

Cognitive flexibility: Another term for mental flexibility or set-shifting. These terms refer to the ability to shift to a different thought or action according to changes in a situation (Hill, 2004).

Context blindness: impairment in the spontaneous use of context in information processing and sense making (Vermeulen, 2015)

Context: Everything in a given situation that influences the meaning of a target stimulus. Context can be external (environment surroundings) or internal (concept, previous experiences, knowledge, expectations, emotions, arousal; Kokinov, 1997)

Emotion: The phenomena that accompany situations that tend to elicit approach and avoidance behaviours (Gaigg, 2012)

Social Game: An idealization of a social interaction. A social interaction reduced to its basic elements (Colman, 1995)

Other-regarding behaviour: This includes behaviours that are directed toward others such as altruistic action, action motivated out of fairness, and cooperative behaviour in the face of incentives to take advantage of others.

Payoff: The gain that results from decision making and that depends on the rules of the ‘social game’.

Players: The decision makers involved in a ‘social game.’

Pot: The amount of any money to be split in a ‘social game’, also referred to as ‘pie’ or ‘stake’. The pot can be made up of money, goods, time.

Preferences: The categorical order in which a person organises the available choices. Rational models suggest that individuals prioritise choices that give an optimal material payoff.

Prosocial: The term prosocial behaviour refers to acts that are beneficial to other people, for instance helping, sharing, comforting, donating, or volunteering, and behaviours that are mutually beneficial such as cooperation (Declerck & Boone, 2016)

Other-regarding preferences: The tendency to care about the motives underlying the action of others during decision making, their payoffs and wellbeing (House et al., 2013) Examples of other-regarding preferences are trust, fairness-concerns, inequity aversion, reciprocity and altruism. These behavioural dispositions have been recognized in the economics literature as important elements for smooth and efficient economic exchanges, for instance when entering formal contracts is not feasible (Camerer, 2003a)

Self-interest: In the context of standard economic models of decision-making self-interest is displayed when an individual is solely motivated to maximize their own gain.

Self-serving bias: The tendency “to conflate [blend together] what is fair with what benefits oneself, thus people tend to arrive at judgments of what is fair or right that are biased in the direction of their own self-interests” (Babcock & Loewenstein, 1997, pp.110).

Social Cognition: The cognitive processes involved in understanding social agents and their interactions.

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DECLARATION NOTE

Originality Statement

This thesis is submitted to City, University of London in support of my application for the degree of Doctor of Philosophy. It has been composed by myself and has not been submitted in any previous application for any degree.

Abstract

When humans interact with one another, the decisions they make often appear to be irrational in a purely economic sense. People are willing to sacrifice resources in order to affect positive outcomes for others and they often forgo opportunities to maximise benefits for themselves in order to avoid disadvantaging others. Explanations for such phenomena remain contested. The current thesis seeks to shed light on some of the factors that contribute to social-decision making by comparing decision making in typically developing individuals and individuals diagnosed with autism spectrum disorder – a condition characterised by difficulties in many of the domains that are suspected to play a role in guiding social-decision behaviour. In four experiments, variants of a paradigm known as the Ultimatum Game were implemented, which requires individuals to decide whether or not to accept or reject fair or unfair monetary offers. In Experiment 1, a one-shot UG was implemented in which participants provided one response as proposer and one as responder. In experiment 2, as responders, participants were asked to decide over intentionally vs randomly made unfair offers while skin conductance response was measured. In experiment 3, a cognitive manipulation was implemented, and participants were asked to respond with and without time pressure to fair and unfair offers made by human proposers. Finally, in experiment 4 participants played as proposers and responders a multi trial Mini UG. Here, participants decide over an unfair offer which is presented four times along with an alternative offer that varies in levels of fairness each time. In addition, across all experiments a number of traits, that are thought to play a role in regulating decision behaviour in this scenario were assessed through self-report and

performance measures, including theory of mind, inhibition, empathising and systemising. The results from the Ultimatum Game task showed that there are no substantial behavioural differences between ASD and control participants (TD). However, in two of the experiments, differences emerged which suggested that the two groups differed in the cognitive processes recruited to respond to levels of fairness. Specifically, in experiment 2 ASD participants were less influenced by whether or not unfair offers were proposed by a human or computer counterpart and in experiment 3 rejection rates were more strongly associated with a measure of theory of mind than in the TD group. These results are discussed in the framework of cognitive theories of ASD and models of economic exchange suggesting that inequity aversion, e.g. Cultural norms, and fairness reciprocity are not stable preferences but differently motivate decision behaviour depending on the context. Further research needs to be undertaken to identify how executive control and dual theories of moral judgements affect decision behaviour in repeated interactions.

1 INTRODUCTION

Theories of social exchange are based on the assumption that decision makers have homogeneous identical preferences and follow rational and logical principles that lead them to optimal choices. However, growing evidence is suggesting a different viewpoint in the factors underlying decision making. Social decision-making studies are showing that diverse motives stemming from individual psychological differences and the interaction with their social environment explain the deviation from the rational model. In this thesis, I examined these two views and present research on the role that individual differences on personality and cognitive style play in social-economic decision making in typically developing individuals (TD) and individuals diagnosed with Autism Spectrum Disorder (ASD).

Decision making in social contexts relies on the ability to understand the intention, emotions and beliefs of others and on the capacity to recognize that others may think differently from ourselves. However, through interaction we learn that also these perceptions may change depending on the context where the interaction takes place, thus the ability to swiftly perceive changes in the context is also necessary for successful judgement of the available choices in a decision-making scenario.

Scientific research on decision making in social contexts has largely focused on social situations where individuals are involved in a social exchange in which there exists a conflict between choices that either favour *the self or the other*. These scenarios usually challenge social norms such as trust, altruism and fairness. The Ultimatum Game (Güth, Schmittberger, & Schwarze, 1982) represents such a situation in which fairness is manipulated and the current thesis will draw on this paradigm to examine social decision making in typically developing (TD) and autistic adults (ASD). This is of interest because ASD is characterised by differences in many of those processes that are thought to play an important role in shaping social decision

making, such as the ability to attribute mental states to others (*mentalizing*), to think logically and systematically about situations (*systemizing*) and to integrate emotion-related processes with ongoing cognitive processes. Examining social-decision making in paradigms such as the UG in this population, can therefore contribute to our understanding of the role of these processes in social decision making as well as contribute to our understanding of some of the core features of ASD.

Before setting out the empirical work of this thesis in Chapters 2-5, the literature review presented in the current chapter will be organised as follows. The first section will provide an introduction to the defining and associated characteristics of autism spectrum disorder (ASD) along with an overview of some of the theories that have been developed to explain these characteristics, particularly focusing on the evidence concerning the social-cognitive domain. This is followed by an account of social decision making from the perspective of game theory, with a particular focus on what game theoretical tasks such as the ultimatum game have revealed with respect to typically developing participants. This section will conclude with a summary of studies in social and general decision making in ASD, although this evidence will be highlighted again, when relevant, in the context of the individual empirical chapters.

1.1 Autism

Autism Spectrum Disorder (ASD) is a heritable and lifelong neurodevelopmental condition, characterized by impaired communication and social interaction and restricted and repetitive interests and behaviours. According to current DSM-5 criteria (DSM-5: American Psychiatric Association, 2013)¹, the social-communication difficulties include deficits in social-emotional reciprocity; deficits in nonverbal communicative behaviours used for social interaction, and deficits in developing, maintaining, and understanding relationships.

¹ Diagnostic and statistical manual for developmental disorders

Restricted and repetitive behaviours encompass stereotyped or repetitive motor movements, use of objects or speech; insistence on sameness, inflexible adherence to routines or stereotyped patterns of verbal or nonverbal behaviour; highly restricted interests and, hypo or hyper sensitivity to sensory stimuli. Although these are the core features of the condition, comorbidity with other conditions is very common: About 70% of the population with an ASD diagnosis have other comorbid psychiatric disorders such as ADHD, depression or anxiety; and medical conditions such as epilepsy, sleep disturbances and gastro-intestinal problems are also common (Simonoff et al., 2008).

Diagnosed cases of autism have increased in recent years, rising from prevalence estimates of 1/150 people in 2000; to 1/68 in 2010 and 1/59 in 2014 (Center for Disease, control and prevention, 2018; <https://www.cdc.gov/ncbddd/autism/data.html/>). However it is not clear yet if the rise in diagnosed cases is due to an increased awareness about the condition, or due to a genuine increase in the frequency of the disorder (Pessah et al., 2008). On balance, the evidence indicates that the true prevalence of ASD is likely to be around 1% of the population around the world and the number of cases in males exceeds those found among females (Baron-Cohen et al., 2011; Bertrand et al., 2001). This may be explained because women are more naturally driven to communication and social interaction, allowing them to compensate for the difficulties in social-communication that are clinically defining of the condition (Lai et al., 2011). It may also be the case, however, that diagnostic tests and assessments are less sensitive to the diagnosis in females on the autism spectrum because these instruments have been developed and calibrated with a ‘male-dominated’ view of ASD.

When autism was first identified by Kanner (1943) and Asperger (1944)² there was no clarity about whether the condition was biologically determined, or if it developed during

² Translated into english by Uta Frith et al., (1991)

childhood as a result of environmental factors. At that time, a damaging theory grew in popularity, which claimed that a poor or disrupted relationship between the new-born child and the caregiver was the most likely cause of the condition – the so-called refrigerator mother hypothesis (Bettelheim, 1967). Since then, the condition has been extensively studied and although its causes remain unclear, it is now undisputed that ASD is a disorder of neurobiological origin. Some factors that contribute to its aetiology have been identified at multiple levels of description: genetic factors, associated with heritability and genetic mutation (Huguet, Benabou, & Bourgeron, 2016); environmental factors, associated with maternal age (Hallmayer et al., 2011; Pardo & Eberhart, 2007); neurobiological factors associated with irregularities in the connectivity between areas of the brain (Di Martino et al., 2014; Kana et al., 2014; Keehn et al., 2013) as well as more focal abnormalities in areas of the ‘social brain’ (Damasio & Maurer, 1978).

Finally, explanations of autism have also been sought at the psychological level, which will be the principal focus of the current thesis. Of most relevance, at this level of description, are theories that seek to explain the core difficulties individuals on the autism spectrum have in multiple aspects of social cognition, which describes the capacity to attend to, recognize and interpret interpersonal cues that guide social behaviour and the processes that allow individuals to adapt flexibly to the demands of social interactions (Baez & Ibanez, 2014; Green, Horan, & Lee, 2015; McDonald, 2013; Happé, Cook, & Bird, 2017). The next sections will provide a more detailed overview of the social-cognitive and emotional characteristics of ASD along with the theories that seek to explain them and with a focus on those factors that, from each theory, contribute to explain decision behaviour.

Social and emotion-related processing models.

Social and emotion-related processes have been the focus of attention in ASD research since the syndrome was first described (Kanner, 1943) and a large number of studies have been carried out that have examined how autistic individuals understand and respond to the emotions of others (see Gaigg, 2012; Harms et al., 2010; Uljarevic & Hamilton, 2013; Nuske, Vivanti & Dissanayake, 2013 for reviews). This area of research is relevant to the current thesis, because, interpersonal emotional processes have been found to play an important role in moderating social-decision making, as explained in more detail in the introduction of Chapter 3.

Despite some inconsistencies in findings, it is generally agreed that, compared to control groups, interpersonal affective behaviours in ASD are characterized by differences in the processing and expression of emotional information. For instance, it is generally found that autistic individuals find it more difficult to identify facial emotional expressions compared to comparison groups, particularly when the emotions displayed are subtle, or complex (see Harms et al., 2010 & Uljarevic & Hamilton 2013). To give an example, Philip et al., (2010) invited 46 adults (ASD & TD, gender and age matched) to do a series of tasks. First, using the Ekman Faces Test from the Facial Expressions of Emotions, FEEST (Young et al., 2002), participants were asked to select a text label (happiness, sadness, anger, disgust, fear or surprise) to describe the emotion expressed in a face presented to them on a computer screen. In a second condition, participants were presented with more a sensitive measure, also from the FEEST – the Emotion Hexagons task. This task although similar in structure to the Ekman test, is more sensitive because the stimuli are computer manipulated (morphed) to generate subtler degrees of expressing different emotions and also emotions that represent a blend of, for example, fear and anger. The two groups performed significantly differently in these tasks, with ASDs consistently performing worse than controls when identifying anger, sadness and fear. In addition, the results showed that the ASD group performed significantly lower than

TDs in the Benton Test of Facial Recognition (Benton et al., 1983), which examines basic face recognition ability. Since previous studies had also demonstrated general face processing difficulties in ASD (Pelphrey et al., 2002; Sasson, 2006), this might indicate that emotion processing difficulties are a consequence of broader face processing difficulties. Other studies, however, have shown that autistic individuals do not only have difficulties identifying emotional information in facial expressions but also in body gestures (Dalton et al., 2005; Libero, Stevens, & Kana, 2014) and intonations of the voice (Demopoulos et al., 2015; Stewart, Mcadam, Ota, Peppé, & Cleland, 2013) suggesting that emotion recognition difficulties are not modality or stimulus specific.

The difficulties autistic individuals have with the identification of emotions in others has also been shown to affect how they respond to and express emotions. For instance, a number of studies suggest that autistic individuals mimic the expressions of others differently (Forbes, Pan, & Antonia, 2016; Helt et al., 2010) and that their emotional expressions are more difficult to ‘read’ than the expressions of typically developing individuals (e.g., Brewer et al., 2016). More generally autistic individuals also demonstrate a lower quality and reduced frequency of social-emotional overtures during social interaction (Begeer et al., 2008) and are less likely to respond with concern or empathy to the emotional distress of others. In pioneering studies by Sigman and colleagues, for example, (e.g., Kasari et al, 1990; Sigman et al., 1992) autistic children were less likely than typically developing children to orient to, and show concern for, an adult who pretended to hurt themselves. Interestingly, however, the autistic children were not entirely insensitive to the emotional expressions of others and often demonstrated typical physiological arousal responses (e.g., Lombardo et al., 2007; Trimmer, McDonald, & Rushby, 2017)

Based on the wealth of evidence that has accumulated, there is now a general consensus that ASD is characterised by atypicalities in multiple facets of interpersonal emotional

processing. However, there is less agreement about the causes of these difficulties and a number of different explanations have been offered. First, *the social motivation* theory argues that human interaction is typically rewarding and that the social emotional difficulties in ASD may be the result of atypical development in the neural network (including amygdala, striatum and orbital-frontal cortex) that would normally mediate the experience and seeking of such social reward (Chevallier, Kohls, Troiani, Brodtkin, & Schultz, 2012a). According to this view, early emerging abnormalities in this social-reward network, makes the autistic child less interested in the social environment, thus compromising the development of a broader social brain network, including regions dedicated to face processing (Kanwisher, 2000) mental state understanding (i.e., superior temporal sulci, medial prefrontal cortex, temporal poles, see Gallagher & Frith, 2003), and empathy/interpersonal affective behaviours (i.e., anterior cingulate cortex, anterior Insula, amygdala, striatum Baron-cohen, 2005; Singer, 2006; Singer & Lamm, 2009).

A second view, proposed by (Bachevalier & Loveland, 2006; Loveland, 2005; Loveland, 2001) is the *self-regulation account*, which suggests that it is not only the perception of social-emotional signals that represents a challenge for ASD but also that the behaviour regulation in response to these signals is compromised. Unlike the social-motivation theory, however, the behavioural self-regulation account suggests that the social-emotional difficulties experienced by autistic individuals do not necessarily arise from a lack of interest in social stimuli, but rather a difficulty knowing what emotional expressions (and social-communicative signals more generally) afford in terms of behavioural responses. In other words, autistic individuals are not socially less motivated, and do not even have fundamental difficulties understanding the meaning of emotional expressions – instead they have difficulties initiating appropriate behavioural responses. This view is in line with the evidence from the studies by Sigman and colleagues (e.g., Sigman et al., 1992; Corona et al., 1998), which found typical

physiological but atypical behavioural responses to the distress of others. Corona et al., measured ASD children's responsiveness to the pretend pain expressed by an experimenter after hurting her knee. The attention and comforting gestures given to the experimenter were quantified by measuring the frequency, latency and duration of attention given to the experimenter (Rated on a 1-6 scale, from no interest to comforting behaviour); rating the facial expression (positive, negative or neutral) in response to the observed pain and by taking cardiac measures. Although ASD's cardiac response was similar to controls, ASD looked at the experimenter's knee less often, for a shorter amount of time in total, and took longer to first look at her. Similarly, other studies have shown that autistic children, although aware of the emotional display of others, were less responsive compared to control groups (Loveland, 1997).

Distinct from both of the perspectives above is a third view; *the interpersonal relatedness* account. Like the self-regulation account, this view also acknowledges that in the context of interpersonal processes, both perception and action need to be considered to understand the socio-emotional characteristics of ASD. However, greater emphasis is placed on the interpersonal bond that is fostered through a child's ability to regulate and co-ordinate their behaviours in response to others. Specifically, Hobson argues that the quality of a child's early interactions with her caregivers sets the foundations for social-cognitive development and the child's emerging ability to identify with the feelings, intentions and attitudes of others (Hobson, 1995, 2012). In autistic children, early interpersonal engagement is disrupted and therefore subsequent capacities never fully mature. Evidence for this view stems from studies which suggest differences in the quality of interpersonal engagement of autistic and non-autistic children. For instance, Hobson & Lee, (1998) showed that autistic children are rated as less engaged with an experimenter during very basic social interaction, i.e. saying 'hello and good bye'. In this study, participants were asked to take part in a ten-minute task, but the focus was on the quality of 'intersubjective engagement' of the child whilst greeting and saying good-

bye to the experimenter, which was video recorded. Ratters blind to the children's diagnosis then watched the recordings to identify indices of intersubjective engagement during the short interaction in the form of verbal or nodding responses, smiling, eye-to-face contact and/or combinations of eye-contact, smiling, verbalization and waving good bye. Relative to typically developing comparison participants, during the greeting, ASD children, made less eye-to-face contact, less smiles, and showed fewer instances where they combined eye-to-face contact with smiling and speaking. Similarly, at the farewell, ASD waved less, and when they did, the gesture was rated as appearing odd.

So far, the three accounts just described consider the ASD developmental trajectory to begin at birth with abnormalities in what Kanner referred to as an 'innate ability to form affective contact with people'. In other words, the theories place considerable emphasis on interpersonal emotional processes. By contrast, an alternative theory considered the starting point of the developmental trajectory of ASD to begin with the abnormal maturation of a cognitive mechanism that would lead to abnormalities also in interpersonal emotional processes. *The mentalizing theory* (or Theory of Mind Theory – ToM), suggests that the disorder begins with the failure to develop a so-called shared attention mechanism, which typically matures around 9 months of age (Baron-Cohen, 1995; Frith & Happe, 2005; see also for a review Boucher, 2012). The mentalizing account rests on the premise that much of our interaction with others is influenced by the basic assumption that others have similar minds to ours. On this basis, we view others as having their own perspective of the world, and we try to understand, describe, explain and predict their behaviour in terms of mental phenomena such as beliefs, desires, intentions and feelings. This tendency to infer mental states to others was first referred to as "Theory of Mind" by Premack and Woodruff (1978), as 'taking an intentional stance' by Dennett (1988), and as 'mentalizing' by Frith (1989).

Similar to the other three accounts described above, the mentalizing theory's proponents agree with the idea that ASD is the result of a social brain dysfunction. For instance, Baron-Cohen (2005; 1995) argues that theory of mind (ToM) is regulated by a distributed circuit involving superior temporal and medial prefrontal regions as well as the amygdala (Baron-Cohen et al., 2000; see also Frith & Frith, 2003; Buchanan, Tranel, & Adolphs, 2009), which are commonly also considered part of the 'social brain'. In Baron-Cohen's view, the components of this system evolved independently and gradually became interdependent to provide increasing flexibility in adapting to ever more complex social environments. More specifically six neuro-cognitive mechanisms are said to comprise the mentalizing system. The Intentionality Detector (ID), Eye Direction Detector (EDD) and Emotion Detector (TED), are the first to mature, and by 9 months of age allow the child to understand agent-object relations in terms of wanting, seeing or being "angry" at something. Although the development of these mechanisms is delayed in ASD, Baron-Cohen argues that these mechanisms are not fundamentally impaired. Next and by 18 months of age, typically developing children develop the shared attention mechanism (SAM) which enables the child to accomplish more elaborate representations and interactions with the world that includes triadic relations between the self, an agent, and an object. This developmental milestone is indicated in typical development by children beginning to show objects of interest to caregivers and generally seek to initiate the sharing of attention with others (Charman, 2003; Charman et al., 1997; Jones & Carr, 2004) for a review (P. Mundy, 2017). The absence of such sharing of attention is the first reliable clinical marker for an ASD diagnosis.

The last mechanisms to develop in Baron-Cohen's mentalizing system, and the mechanisms that are argued not to reach functional maturity in ASD, are the Theory of Mind Mechanism (ToMM) and The Empathizing System (TESS), which are responsible for 'cognitive' vs. 'affective' theory of mind processes respectively. ToMM is thought to allow

children to attribute mental states to others and to themselves, therefore providing an understanding that others may hold different beliefs from our own, and that the intentions and desires that guide their behaviour may be different from those of our own. TESS, on the other hand, is thought to allow children to respond to the mental states of others with appropriate empathy and emotion (TESS). These two mechanisms are usually (Bowler et al., 2005) but not always compromised in ASD (Baron-Cohen, 2001; Boucher, 2012; Frith, 2001) and there is some suggestion that particularly cognitive ToM is a source of difficulty whereas affective ToM processes may be relatively preserved (see Baron-Cohen, Tager-Flusberg & Lombardo, 2013; Mazza et al., 2014) although the evidence here is mixed. It is worth noting that, even when autistic individuals appear to engage mentalizing skills, they often do so through controlled and effortful reasoning, rather than intuitively (Senju, 2012). Since this distinction between effortful and intuitive mentalizing will be relevant to some of the evidence presented in later chapters, it is useful to consider how mentalizing is typically assessed.

The assessment of ToM has been possible by implementing tasks for children and adults. The False Beliefs task, has been the most widely used ToM test for children (Wimmer & Perner, 1983). It typically involves presenting children with a short narrative (enacted with two dolls, or two-real people) in which Sally has a basket and Anne has a box. Sally puts a marble in the basket and goes out for a walk. While she is outside, naughty Anne takes the marble from the basket and puts it into her own box. Now Sally comes back from her walk and wants to play with her marble. Children are then asked, ‘where will Sally look for the marble?’. The obvious answer, that Sally will look for the marble inside her basket because she thinks the marble is still there, is usually given by typically developing children from the age of around 4 years (Perner & Lang, 1999), whereas autistic children at the age of 4-6 consistently show difficulties with this task and respond that Sally will look for the marble in the box (Baron-Cohen, Leslie, & Frith, 1985; Senju et al., 2009).

The smarties task, also known as the ‘unexpected contents task’ (Perner, Leekam, & Wimmer, 1987) is another test developed with low requirements for language abilities, to assess mental state understanding in self and others. In relation to self, the task assesses understanding that you yourself can be misled, or be deceived, whereas in others it probes recognition that others can be misled or deceived. In this task, the participant is shown a Smarties tube and is asked what they think is inside. Once they respond, the participant is shown that the tube actually contains a pencil. The tube is then resealed with the pencil inside and the participant is asked two ‘false belief’ test questions. The ‘Other-person’ test question requires the participant to predict what another person, who has not yet seen the actual contents of the smarties tube, would believe was inside (before they were allowed to look). This question is designed to assess the participant’s awareness of another person’s false belief. Participants are also asked what they, themselves, thought the tube contained before they were allowed to look inside. This is the ‘Self’ test question and is thought to assess the participant’s awareness of their own prior false belief. Until the age of between 3 to 4 children assume other people will expect to find pencils in the smarties tube. Furthermore, they are unable to appreciate that their past representation of an object was different from their current representation (Gopnik & Astington, 1988). Children claim that they expected to find pencils when they first opened the box, a phenomenon called hindsight bias. Individuals with ASD perform as poorly on the self-test question as they do on the other person test question: they will expect the other person to know what they themselves know, i.e. that the tube is full of pencils instead of smarties, as they do not recognize that the other person has not actually seen the pencils in the container (Fisher, Happé, & Dunn, 2005).

As interest in the mentalizing account has grown over the years, other tasks have been developed and adapted for research purposes to address mentalizing in participants of varying ages and ability levels. For instance, the Strange Stories task (Fletcher et al., 1995; Happé,

1994) is suitable for both children and adults. In this task participants are presented with a set of 24 short written vignettes about everyday situations where people say things they do not literally mean. The 12 themes include irony, double bluff, lie, white lie, persuasion, pretence, figure of speech, joke, misunderstanding, appearance/reality and forgetting. In all cases, participants are asked to answer a question about the story that probes their comprehension of the text and a mentalizing question which usually takes the form of ‘Why did X say Y’? Answers are given in a self-paced fashion and scored on a 0-2 scale according to the extent to which participants attribute mental states to others to explain their behaviour (White et al., 2009, pp. 1109-1117). ASD participants generally perform poorer on this task, which has been interpreted as the result of a lack of understanding of mental states and context processing rather than due to poor text comprehension (Jolliffe & Baron-Cohen, 1999; Murray et al., 2017). Other vignette based tasks include recognition of faux pas (Baron-Cohen et al., 1999; Gregory et al., 2002; Stone et al., 1998), which describes a particular case of an action reflecting an involuntary socially inappropriate behaviour. The faux pas is presented to participants in a series of stories, (10 for children and 20 for adults), which resemble everyday situations. After reading the story participants answer questions to assess comprehension, as well as questions about the intention and beliefs of the characters. Similar to the Strange Stories Test, autistic individuals tend to have difficulties on the faux pas test (Baron-Cohen et al., 1999) although autistic adults frequently perform fairly well, which has been linked to moral development and learned (rehearsed) abstract knowledge about social rules (Stone, 2002).

Although the Strange Stories and Faux Pas tests are generally appropriate for use with older participants, one of the main disadvantages is that performance depends very heavily on participant’s verbal and general intellectual ability. Moreover, because the tasks necessarily provide participants with ample time to read and consider the text carefully, participants might arrive at the ‘correct’ answer not by engaging mentalizing but by drawing on their knowledge

of social conventions – i.e., by ‘hacking out’ a solution. To overcome these limitations some non-verbal tasks have been developed and tasks that are thought to rely on a more intuitive ability to attribute mental states to others. These tasks include the Animations task, (Abell, Happé, & Frith, 2000; Castelli et al., 2000; Salter et al., 2008) and the Reading the mind in the eyes test (RMIE - Baron-Cohen et al., 2001). In the Animation task, participants are presented with short animated clips showing moving triangles. Participants are required to give a concurrent verbal description of what they think is happening. At the end of the animation they are asked to categorize the video either as depicting: “no interaction” (random), “physical interaction” (goal directed, e.g., chasing one another), or “mental interaction” (e.g., mocking) and, for ‘mental interactions’ answer questions about what the mental states portrayed may have been. ASD participants usually produce fewer accurate mentalizing descriptions of the animations and are less accurate in correctly identifying the mental states the triangles are meant to enact (White et al., 2011). The reading the mind in the eyes test (RMIE - Baron-Cohen et al., 2001) requires participants to recognize mental states in photographs of the eye-region of faces, by selecting one of four words that best describe the expression. The test is primarily thought to be a measure of affective theory of mind (TESS) since many of the mental states that need to be inferred are emotional and performance appears to dissociate from other, cognitive, theory of mind tests (see Oakley, Brewer, Bird & Catmur, 2016).

It has become one of the most widely used tests of mentalizing for adults, in part because it can be administered and scored relatively easily but also because it is not as susceptible to ceiling effects as the other tasks, generally yielding a relatively normal distribution of performance across individuals. Because of these advantages, the RMIE will be used as a measure of mentalizing in the experiments reported in this thesis and a fuller description of the test will be included in Chapter 2.

From Mentalizing to Systemizing and Empathizing

Despite the differences among the theories outlined in the previous section (social motivation; self-regulation; interpersonal engagement & mentalizing), all share the idea that ASD is primarily characterised (and probably caused) by abnormalities in fairly domain-specific social-cognitive or social-affective processes. This provides for good explanations of the core social-communication impairments that clinically define the disorder, but the theories that are based on such domain-specific assumptions do less well in explaining the broader cognitive characteristics of the disorder and also some of the non-social clinical characteristics such as the presence of repetitive and stereotyped behaviours and interests. To account for these additional features of the disorder, the mentalizing theory was expanded to include the suggestion that difficulties attributing mental states and feelings to others might be accompanied or even offset by superior logical reasoning skills in ASD. Specifically, Baron-Cohen (2002) proposed the so called Extreme Male Brain (EMB) Hypothesis of ASD, which is based on the premise that there are two brain types that mature in gender specific ways due to the hormonal environments in which male and female brains mature. In this view the female brain is biased to *empathizing*, while the male brain is geared toward *systemizing* (Baron-Cohen, 2005; Goldenfeld, Baron-Cohen, & Wheelwright, 2005). *Empathizing* is the drive to identify another person's emotions and thoughts, and to respond to these with an appropriate emotion (i.e., a concept that necessitates ToM). Systemizing, on the other hand, is the drive to analyse the variables in a system and to derive its underlying rules. While empathizing makes it possible to predict another person's behaviour on the basis of their thoughts and feelings, systemizing would facilitate an understanding of behaviour in terms of fairly rigid rules. Typically, people would possess these abilities in equal measures, with the average woman tending somewhat more toward empathizing than systemizing, and the average man being more inclined to systemizing rather than empathizing. According to the Extreme Male Brain Hypothesis, autistic people have an unusually strong tendency for systemizing instead of

empathizing, thus leading to a clinical profile that is characterised by weaknesses in social-cognitive and social affective domains but strengths in areas such as computing, engineering and mathematics (Baron-Cohen et al., 2003).

Most of the evidence in support of the Extreme Male Brain Hypothesis stems from studies employing the Empathizing and Systemizing questionnaires developed by Baron-Cohen (2002) to capture these processing styles. Each questionnaire asks individuals to indicate to what extent certain behavioural and cognitive traits are characteristic of them, which allows for the calculation of separate empathizing and systemizing scores as well as a difference score that reflect the extent to which someone leans more toward one vs. the other type of processing. According to Baron-Cohen, the discrepancy between E and S can be used to classify individuals into one of five profiles. Type E ($E > S$): individuals whose empathy is stronger than their systemising. Type S ($S > E$): individuals whose systemising is stronger than their empathy. Type B ($S = E$): individuals whose empathy is as good (or as bad) as their systemising (B stands for 'balanced'). And finally, two types of extremes; Extreme Type E ($E \gg S$) includes individuals whose empathy is above average, but who are impaired in systemising and extreme Type S ($S \gg E$), which includes individuals whose systemising is above average, but who are challenged when it comes to empathy.

While typically developing individuals tend to score fairly similarly on both questionnaires (i.e., Type B), women often achieve greater empathizing than systemizing (Type E), and men greater systemizing than empathizing scores (Type S). Data from groups of autistic individuals consistently shows considerably higher systemizing than empathizing scores (i.e., an extreme Type S male profile of scores). This pattern of preferring systemizing is thought to contribute to the urge of ASD individuals to collect information within restricted areas of interest so as to understand the underlying rules governing a certain topic. Additional evidence for strong systemizing in ASD stems from studies comparing the performance of TD and ASD

participants in physics and mathematics in school tasks. Performance of ASD children (8-11 years old) was reported to be above the level of typical teenagers, which suggests that compared to the general population autistic individuals have a remarkable ability to understand and manipulate complex systems such as scientific phenomena and machines (Baron-Cohen, et al., 2001). As discussed in more detail shortly, the E-S concept is of interest in relation to social-decision making where both empathising (and affective theory of mind) as well as systemizing are thought to play a role.

All in all, the theories of ASD outlined thus far argue that the core clinical difficulties of ASD result from atypicalities specifically in social processes (see Gaigg, 2012 for a review). However, whilst these theories provide a useful framework for understanding the core social-communication difficulties associated with ASD, they fall somewhat short of providing explanations for some of the non-social characteristics such as sensory processing difficulties and repetitive behaviours. Thus, a number of other theories have been developed that are more domain-general in nature.

Cognitive perspectives of Autism.

The core characteristics of ASD have not only been explained with reference to abnormalities in relatively domain-specific social-affective or social cognitive processes but also in terms of more domain general differences in the function of certain perceptual and executive function processes. Although these approaches to ASD will not be as pertinent to the topic of the current thesis as the theories just outlined, it is important to consider the evidence for them at least briefly to provide a comprehensive picture of the autistic phenotype.

Executive Functions

Executive functioning (EF) refers to the ability to flexibly allocate mental resources to guide thoughts and actions in light of internal goals and a considerable amount of evidence

suggests that ASD is characterised by difficulties in at least some facets of EF (Hill, 2004; Robinson et al., 2009a). EF relies on top-down control mechanisms to regulate goal-directed behaviours and includes functions such as cognitive and behavioural inhibitory control; working memory and cognitive flexibility (Diamond, 2014). Built on these core domains are other functions such as reasoning, problem solving and planning, which are all supported by frontal areas of the brain, particularly the prefrontal cortex (Duncan & Owen, 2000).

The evidence in relation to EF in ASD suggests that working memory and cognitive flexibility constitute particular areas of weakness in this disorder, with the evidence concerning other EF domains painting a more mixed picture (Brunsdon & Happé, 2014; Demetriou et al., 2017). For instance, a number of studies have demonstrated working memory impairments in ASD using n-back tasks, which require participants to monitor sequentially presented stimuli for certain repetitions that are separated by a certain number (n) of intervening stimuli. Autistic participants typically perform worse at lower number of intervening stimuli, suggesting that they have difficulties maintaining and/or updating the stimulus sequence in working memory. Similarly, autistic individuals have also been shown to have difficulties on measures of cognitive flexibility such as the Wisconsin Card Sorting Test (WCST; Berg, 1948; Grant & Berg, 1948). Here participants are asked to sort cards which show different numbers of symbols in different colours according to rules that the participant needs to discover through trial-and-error and feedback. Unbeknownst to the participant, the rules that govern the feedback are changed periodically so that, at first, sorting according to the colour of the symbols is correct and at a certain point sorting by the number of symbols is correct. A considerable amount of evidence indicates that autistic individuals have difficulties switching from one rule to another, thus making perseverative errors (i.e., continuing to sort according to a rule that no longer yields positive feedback) (Kaland, Smith, & Mortensen, 2008; Pellicano, 2010; South, Ozonoff, & McMahon, 2007)

According to a number of authors, EF dysfunction might contribute to a number of the core clinical characteristics of ASD, including in both the social and non-social domains (Ozonoff et al., 1991; Russell, 1997). Specifically in the non-social domain EF dysfunction can account for need for sameness, strong tendency to stick to routines and stereotyped behaviour, lack of impulse control, and difficulties switching between tasks and initiating novel actions (Miller et al., 2015; Robinson et al., 2009b), all of which can lead to perseverance but also be detrimental for social interactions, which require flexibility. For instance, in day-to-day social life, we adapt to novel and possibly unexpected situations by drawing on our experiences through which we learn about agreed-upon conventions and views on how to behave, known as social codes. Through learning and experience we become aware that some of these codes (in fact most of them) are not universal and what is acceptable in one situation with a specific group of people may not be acceptable in a different situation or a different group of people. This learning involves the ability to monitor and understand other's point of view (i.e., ToM) but also the ability to exert self-control to inhibit context-inappropriate responses and more generally to adapt flexibly to different circumstances. Failure to engage the EF system would compromise this latter ability and decrease the flexible selection of behaviours that are appropriately adapted to different social exchanges (Hughes, 2001; Leung et al., 2016) in a way that is expected by other people involved in the interaction. As discussed in greater detail in chapter 2, some evidence already indicates that autistic individuals have difficulties adapting their behaviours flexibly as a function of the outcomes of their decisions in certain gambling tasks (e.g., Yechiam et al., 2010; Johnson et al., 2006), suggesting that EF difficulties may also impact on social decision making.

Weak Central Coherence / Enhanced Perceptual Functioning:

During the late 1980s and early 1990s a series of studies documented a phenomenon in ASD that could neither be explained by the mentalizing, nor the EF theories of the time –

namely that autistic individuals appeared to have a very detailed-focused perceptual style, often at the expense of ignoring ‘the bigger picture’. Clinical anecdotal evidence, for instance, suggested that autistic children often completed puzzles even when the puzzle pieces were face-down! Other reports suggested that autistic children often failed to recognise familiar adults because of changes in clothing or hairstyle (see Frith, 1989). This led Frith and colleagues (see Happé & Frith, 2006, for a review) to suggest that ASD was characterised by what they called *weak central coherence* (here after, WCC), which they defined as an impairment in the processing of global unifying meaning or gestalt, in the face of preserved processing of feature information and local detail.

A considerable amount of evidence has accumulated in support of the WCC from studies that show that autistic individuals tend to outperform comparison participants on tasks that require participants to identify details in complex global shapes (e.g., Shah & Frith, 1983) or to assemble puzzles for which the resulting global form makes the assembly of the local pieces generally difficult (e.g., Shah & Frith, 1993; Happé, 1996). Since the initial formulation of the theory, however, the emphasis has shifted from the notion that autistic individuals are impaired in processing the global picture or ‘gestalt’, to the suggestion that they are biased to process local detail, which can often lead to a detriment in processing global information. For example, Mottron and colleagues, proposed that the pattern of observations across WCC-type tasks is a reflection of superior low-level perceptual processes that can, under some circumstances, interfere with otherwise intact global perceptual processes -the so called Enhanced Perceptual Functioning (EPF) theory (see Mottron et al., 2001; 2006). Similarly, in their own review of the theory, of more than 50 studies, Happe and Frith (2006) concluded that the evidence is robust for a local bias rather than for impaired global processing.

Similar to EF difficulties, WCC is thought to have consequences for some aspects of the social difficulties in ASD (Russell et al., 2012) and not only the non-social characteristics.

For instance, WCC has been argued to contribute to the difficulties ASD have with interpreting gestures and body language, which need to be processed coherently and as a part of the wider context otherwise resulting in an inaccurate interpretation of the social overture and the interaction. WCC has also been offered as an explanation for the face emotion processing difficulties that characterise ASD, as well as some of the language difficulties. Specifically people with autism often take things literally because they pay less attention to the context in which language is used (Wang et al., 2006 ; Jolliffe & Baron-Cohen, 2001).

As this overview of the clinical and broader cognitive characteristics of ASD illustrates, the disorder affects many different processes and abilities that contribute to a clinical picture that is characterised primarily by difficulties in social communication and interaction. As the next section will illustrate, many of the social-cognitive processes that are considered to function atypically in ASD are thought to play an important role in social decision making. The next sections will first cover aspects of general decision making in the autism, followed by social decision making in the neurotypical population, with a particular focus on game theory, before returning to what we know about social decision making in autism.

1.2 Social Cognition & Social decision-making

Social decision-making falls under the umbrella of social cognition. In ability terms, social cognition is the capacity to attend to, recognize and interpret interpersonal cues that guide social behaviour (McDonald, 2013). In their review, and ahead of presenting some other definitions, Happé, Cook, & Bird (2017,p.244) define social cognition³ as “the processing of stimuli relevant to understanding agents and their interactions”. Other definitions (Baez & Ibanez, 2014, p.2) go on to make specific the link between social cognition and context: “it is

³ Cognition in this framework includes emotion (Ruff & Fehr, 2014)

a complex set of processes sub-serving adaptive social interactions”. The structure of social cognition is not yet fully defined, however broadly speaking, social cognition involves a complex set of processes sub-serving adaptive social representations and interactions (mind reading, emotion recognition, decision making, moral judgement, reinforcement and learning) and for each of these processes different strategies are involved depending on the specific context. With the exceptions of reinforcement and learning which are not part of this research project, these processes are explained in detail in chapters 2-5.

Since general decision making is involved in social decision making, we describe first what is known about general decision making in the Autistic population, and then we go into the specifics of social decision making in the general population before returning to the autistic population and the description of its behaviour during social decision making.

General Decision-Making Studies in ASD

A number of studies have investigated personal non-social decision making in ASD, which suggest that compared to typical controls, ASD participants show less response to contextual cues, more consistency in the choices they make (De Martino et al., 2008) and less reliance on intuitive thinking styles (Brosnan, Lewton, & Ashwin, 2016). For example, De Martino et al, required participants (IQ and aged matched adults with ASD & TD controls) to choose between a sure option and a risky gamble while skin conductance (GSR) was measured. The monetary prospects were presented as either loss or gain. For example, if participants initially received £50, they were then required to choose between the options of gambling with a 40% chance of keeping all £50 and a 60% chance of losing all £50, and a sure option framed either as a gain “keep £20” or a loss “lose £30”. The two groups did not differ in their decision behaviours and the net gains they achieved. However, behavioural data showed that ASD had a reduced susceptibility to the framing effect, i.e. their choices were less affected by whether

an outcome was described as ‘keeping’ or ‘losing’. Additionally, although higher levels of GSR were observed in ASDs they showed no difference in GSR response to loss and gain framing, unlike control participants who showed a stronger response to loss-framed outcomes than gain-framed outcomes. The authors argued that their results indicate that ASD participants fail to incorporate emotional context into the decision-making process. This reduction in the framing effect, although normative, may reflect a difficulty in the ability to take into account subtle contextual cues that are part and parcel of making decisions in the uncertain social world.

On the other hand, Brosnan, Lewton, & Ashwin, (2016a) examined the relation between ASD and reasoning styles. In their study, participants (young adults with ASD & TDs) completed The Rational-Experiential Inventory-Short, a self-report questionnaire which measures engagement in, and enjoyment of cognitive activities (Rational component) and engagement and confidence in one’s intuitive abilities. In addition, participants also completed the original version of the Cognitive Reflection Task (CRT), a task in which participants are presented with three questions that have a salient intuitive answer that is incorrect, thus requiring deliberation to find the correct answer. Behavioural results from the CRT showed that accuracy was higher in the ASD group, and these participants self-reported lower intuition levels compared to TDs on the Rational-Experiential Inventory-Short. Thus, the results suggested that autistic individuals have a tendency towards deliberative rather than more intuitive reasoning, which fits with the notion of increased systemizing in ASD as postulated by the extreme male brain hypothesis. More details about the CRT are given in Chapter 5 of this thesis. Together with the results of De Martino et al., (2008), these two studies provide evidence to suggest that there is a bias away from context-sensitive intuitive thinking and ASD may be associated with a greater tendency to engage more explicit rule-based analytic thinking.

Other aspects of the more general decision-making literature also point toward more deliberative rather than intuitive decision-making styles in ASD. For instance, studies using

self-report test batteries show that compared to TD individuals, ASD participants more frequently report experiencing difficulties in day-to-day decision making that would typically rely on intuitive rather than more deliberative processes. In Luke (2012), for example, ASD participants reported difficulties in decision making when decisions needed to be made under time pressure, requiring changes in routine or talking to others. In this study, ASD participants significantly more often than TDs also reported that they experienced higher levels of anxiety as a result of, and during decision making, as well as more decision-making avoidance. Both groups, however, reported similar degrees of reliance on rational decision styles suggesting that situations that would typically encourage reliance on intuitive decision making are experienced as more stressful for ASD participants because of the limitations they impose on relying on more deliberative processes. These results were further supported by Levin et al (2015) who, in addition to analysing data from self-report questionnaires, did a thematic analysis of data acquired through face-to-face interviews with young adults (TD vs ASD). And a study by Gaeth et al. (2016), who examined decision making in the general population in relation to self-reported autism-related traits, also supported the notion that such traits are related to a tendency for more deliberative rather than intuitive decision making styles. Specifically, participants who were classified as meeting cut-off criteria for ASD on a self-report measure reported to be less impulsive decision makers.

In all three studies discussed above, the authors, Levin et al (2015), Gaeth et al. (2016) Luke (2012), are cautious about making generalizable claims based on their data, noting that the results should be considered preliminary and exploratory. They did this primarily for two reasons: First, selection criteria of ASD participants did not necessarily include the clinical verification of ASD by the experimenter, which raises questions about the extent to which the observations truly reflect characteristics of ASD. Second, in all three cases data was collected using a combination of standardized and unstandardized instruments, which questions the

validity of the data. Nevertheless, the data across studies appear to be consistent in indicating that ASD may be characterised by a more deliberative rather than intuitive decision-making style, which, in the context of game-theoretical paradigms discussed earlier, might lead to the expectation of more rational (economically speaking) choices.

Table 1.1 Summary of Studies in decision making in ASD

Reference	Features	Paradigm	Interaction ⁴	Participants			Results
				TD (ASD)			
			Human	PC	No.	Age	
(De Martino, et al., 2008)	Framing effects	Gambling	X	X	15 (14)	34	ASD are less sensitive to the experimental context
	GSR						ASD high risk averse
							ASD showed absolute higher GSR
							Levels of GSR were unaffected by (Gaining vs Loosing)
(Chiu et al., 2008a, 2008b)	Reputation	Iterated game		X	16 (14)	15	ASD and TD made similar decisions as trustees and investors
	Brain activity (fMRI)						Groups showed different brain activity patterns
(Wako Yoshida, Dolan, & Friston, 2008)	Executive Function	Stag-hunt game		X	17 (12)	32	ASD and TD Groups have similar reaction times, earnings and cooperative rates.
	Cooperation						Less strategy's changes were observed in the ASD group
	Accuracy-rewarded						High IQ levels were associated with higher levels of cooperation
(Izuma et al., 2011)	Reputation	Dictator	X	X	11 (10)	29	In the ASD group the presence of other does not increase prosocial behaviour or reduce reaction time.
	Mood						
	Reaction Time						
	Other's presence (CPT)						
(Luke et al, 2012)	General Decision-Making Style	Questionnaire (Standardized		X	40 (38)	34	ASD reported significantly more

⁴ It refers to whether participants interact with another human participant or with a computerized agent.

	Inventory (GDMS)	and not standardized)					decision avoidance and higher levels of anxiety
	Self -reported anxiety	Self -reported					Time pressure, routine changes and talking to other were significantly more often reported by ASD to be detrimental to daily decision making.
	Cognitive style						Reported reliance on the rational or dependant styles was not significantly different between groups (TD vs ASD).
(Cage et al., 2013)	Reputation	Dictator	X	X	20 (19)	34	Responses to the observer effect were not predicted by ToM levels.
	Theory of Mind						
	Confederate						ASD were not affected by the observer effect when making donations to charity
							Reciprocal behaviour in human receivers similarly affect TD and ASD.
(Levin et al., 2015)	Theory of Mind	Self -reported	X		15 (15)	18-30	Less likely to make intuition based- decisions
	Decision making style	Interview					More risk averse
	Social Functioning Scale						
(Brosnan et al., 2016)	Cognitive and thinking style	CRT			18 (17)	29	Levels of ASD are associated with lower intuitive and greater deliberative reasoning styles.
	Dual Process Accounts	Self -reported (standardized)					
	(E-S) Theory						
(Gaeth et al., 2016)	Decision making style	Self-reported (standardized)		X	91 (91)	31-37	Thinking Style, Attitude Toward
	Self-assessment for ASD traits.	Mturk					Risk and Perception of Social Norms are

								predictive of difficulties in everyday decision ASD was associated with more decision- making difficulties at home, school and work. ASD recognized problems with personal relations but failed to acknowledge the significance in their lives
(Pantelis & Kennedy, 2017)	Theory of mind Strategic reasoning	Beauty Contest.	X	X	51 (30)	26		ASD and TDs showed similar levels strategic Reasoning and response distribution.

Social decision Making

There are commonalities between social and non-social decision making: Both require the evaluation of outcomes, are influenced by learning from experience, and often involve the formulation (explicitly or implicitly) of predictions of the consequences of choices. However, in social decision making, these factors are all intertwined with an inherent uncertainty about the behaviour of others. Unlike in non-social personal decision making, where an individual need only to consider their own preferences (e.g., how much risk to take to achieve certain outcomes, how soon an outcome should be achieved, how much effort to exert to achieve a certain outcome etc.), in social decision making, individuals consider not only such personal preference but also the effect of a potential decision on one or more other people. Therefore social decision making relies to a great extent on the ability to create an accurate model of other people's goals and intentions (Lee & Harris, 2013). Examples of social decision making include how two people agree on the strategies to achieve a common goal, or to achieve an individual goal that depends on how the other person behaves.

Social decision-making research is concerned with understanding how humans reach decisions that affect and are affected by others (Sanfey et al., 2003); decisions that are therefore typically informed by both self and other-regarding preferences (Lee, 2008; Rilling et al., 2008). Most people successfully accomplish social decision making by flexibly engaging different cognitive mechanisms to strategically and simultaneously process information from social and non-social domains (Frith & Frith, 2008a; McDonald, 2013), however there is also evidence suggesting that this flexibility may be absent in individuals with brain lesions in specific areas of the cognitive and reward network and for people with psychopathological conditions such as schizophrenia (Green et al., 2015) and autism (Wass, 2011), the latter of which is the focus of the current research.

One of the challenges in research in social decision making is how to effectively operationalise and mimic in a laboratory setting the complexity of the context in which naturalistic social decisions are taken and to isolate the factors that affect social decisions. In recent years, a body of work has emerged that seeks to overcome these challenges by using relatively simple game theoretical scenarios to emulate the social environment and allow easier examination of the social decision-making process. The main reason for the growing interest in these paradigms is that ‘good’ performance requires not just a consideration of the options from the decision maker’s perspective, but also from the perspective of at least one other participant in a given scenario. Thus, the outcome to a player is contingent on the choices made independently by two or more players. In games of this nature, a player can benefit from considering the perspective and goals of other players, thus implying a degree of mentalizing.

It is worth noting, that game theory paradigms are not simulations of the real world, and do not necessarily represent the structure and the relations that evolve in social situations. The games do, however, mimic some of the demands that are involved in social decision making and are often administered in an ecologically valid way by ensuring that the decisions

participants take have real consequences for themselves and others they interact with (e.g., losing/losing/taking/giving money). Therefore, in these paradigms a human interaction is reduced to its simplest form and each experimental situation provides a pre-determined number of choices that participants can make, thus providing some experimental control over many of the factors involved in social behaviour (Wang, Yang, Li, & Zhou, 2015). The next section, will provide a general overview of research on decision making in game theoretical paradigms, followed by a section that focusses on the emerging literature in this area involving participants with an ASD diagnosis.

Social decision making and game theory.

Game theory is a mathematical model for the study of human conflict and cooperation within a competitive situation. The key pioneers of game theory were mathematicians John von Neumann and John Nash, as well as economist Oskar Morgenstern (Ellison, 1988), who introduced the concept of a “Game” as a metaphor for interactions with pre-defined rules and consequences. Game theory seeks to describe decision making in such interactions by assuming that decision makers behave fairly rationally to minimise losses and maximise gains. Game theory has provided a very useful framework for formally describing social decision behaviour and a number of game theoretical paradigms have been developed to examine how human behaviour is affected by factors such as rewards (punishment), altruism, reputation and cooperation. As the evidence described in forthcoming chapters of this thesis demonstrates, experimental results have shed light on the complex nature of human interaction, which often violates the assumptions of economically maximising ‘rational’ decision makers.

The simplest games involve two players, who make decisions independently from one another, with no opportunity to discuss the decision with, or even see, the other player. Players make a choice from two or more options, and financial payoffs for each player depend on the

combination of choices made by the two players. For example, in the Prisoner's Dilemma paradigm (Colman, 1995), two players are asked to decide whether or not they wish to cooperate with the other player to obtain, for example, some financial reward. The two players must make the decisions independently and they are told that if neither of them cooperates, the earnings will be lower (e.g., £1 for each player) than if they both decide to cooperate (e.g., £3 for each player). Critically, they are also told that if they choose not to cooperate, while the other player cooperates, the earnings will be greater than in any other scenario for themselves (e.g., £5), whilst the other player will not receive any payment. In One-shot games, it would seem most rational not to cooperate since such a decision would guarantee earnings of at least £1 and possibly even £5, whilst cooperation might result in no earnings and at best £3. Thus, the dilemma is that individually, players are always better off defecting than cooperating, no matter what the other player chooses to do. Yet mutual defection leads to a substantially worse financial outcome than mutual co-operation. Perhaps because of this, although the economically rational is for both players to defect, in most studies, a sizeable proportion of players chooses to cooperate (see, e.g., Sally, 1995).

Similarly, in the Ultimatum Game, which will be discussed at greater length shortly, one of two players (the proposer) is given the opportunity to split an amount of money (e.g., £10) with the other player (the responder). If the responder accepts the amount offered, the money is paid out accordingly but if the responder rejects, neither player receives any amount. Rationally, the proposer should offer the minimum amount possible under the assumption that a rational responder should accept any offer greater than 0. By contrast, however, it is consistently found that proposers usually offer 50% of the pot and responders typically reject offers that are less than 30% of the pot (Camerer, 2003c; Güth & Kocher, 2014; Kahneman, Knetsch, & Thaler, 1986a). The irrational nature of the proposer's behaviour is even more striking in a non-strategic version of the Ultimatum Game known as the Dictator game in which

responders have no choice but to accept the proposed offer. Despite the fact that proposers in this scenario are guaranteed to receive the money they choose to allocate to themselves, they often give at least some to the responder (Kahneman et al., 1986).

As this brief overview of some of the game theoretical literature illustrates, human social decision making often violates assumptions of economically rational behaviour. A considerable amount of evidence suggests that a number of interacting factors influence the magnitude of the deviations from rational decisions, including factors related to the decision maker such as their personality traits, their social-cognitive and social-emotional dispositions and their cultural background (Ruff & Fehr, 2014) but also contextual factors related to the game-theoretical scenario, such as any information about the other players involved (e.g., their socio-economic status or character), or manipulations of the nature of the task (e.g., single vs. multi-trial interactions; the size of potential gains and losses, etc). Given the relatively simple nature of game theoretical paradigms and the fact that they provide ecologically valid insights into the nature of human social interaction, it is somewhat surprising that only relatively few studies have examined social-decision making through such paradigms in ASD.

Game theory in autism

Hill, Sally & Frith (2004) were among the first to examine the possible consequences of theory-of-mind impairments in autism on decision behaviour in a version of the prisoners' dilemma paradigm. Fifteen ASD adults and 15 age-matched TD adults were invited to play a set of three multi-trial (16 trials) prisoner's dilemma involving either computer or human counterpart players. In two of the games, competition was promoted by encouraging participants to win as much money as possible, once whilst playing with a human counterpart (the experimenter), and once whilst playing with a computer counterpart. In the third game, they played with the human partner, a confederate, and cooperation was encouraged by telling

participants that any gains would be split between the two players at the end of the trials (though players were informed about their gains on a trial by trial basis). In addition to the prisoner's dilemma scenarios, participants also completed a series of first and second order theory of mind tasks, which revealed the expected group differences whereby the ASD group performed worse⁵. Contrary to predictions, however, there were no group differences in the responses to the different versions of the prisoner's dilemma games, despite the fact that both groups were sensitive to the different instructions that encouraged either more or less co-operation. Interestingly, neither group demonstrated differences between the two types of counterpart players (human vs computers). Specifically, in interviews following the tasks participants reported using the same strategy when playing either of the partners, concerning themselves mostly with maximising their rewards than thinking about the feelings and thoughts of the partner. Furthermore, there was no relationship between ToM performance and levels of cooperative behaviour.

Downs & Smith (2004) also observed no group differences between 10 autistic children and a non-clinical comparison group on a multi-trial 'tit-for-tat' prisoner's dilemma game, in which an imaginary counterpart player always made the decision that the participating child had made on the previous trial. The rate of co-operation was similar between the autistic and non-clinical comparison group, despite the fact that groups differed on a social-emotional test which indicated that autistic children had characteristic difficulties in attributing feeling states to others. Together with the findings by Hill et al., (2004), this suggests that despite social-cognitive difficulties, neither children nor adults with an autism spectrum diagnosis differ in terms of their social-decision making, at least as far as the prisoner's dilemma scenario is concerned.

⁵ Theory of mind tasks used: 1st order Sally- Anne task (Wimmer & Perner, 1983); 2nd order the Coat story (Bowler, 1992).

More recently, Tayama et al., (2012) also carried out a tit-for-tat prisoner's dilemma experiment with 29 Japanese ASD adolescents and 28 age and IQ matched controls. Somewhat differently to the study by Downs & Smith (2004) and Hill, Sally & Frith (2004) the authors of this study used a variable pay-off matrix whereby repeated decisions not to cooperate would lead to progressively worse losses. The TD group were outperformed by the ASD group in terms of the overall number of points won. It was reported that while TD participants pursued personal gain by strategically trying to defect, and adjust their strategy to win points, the ASD group adopted a more consistent strategy probably motivated by a desire to discover the 'hidden' rules of the game. The authors interpreted their findings in line with Baron-Cohen's extreme male brain hypothesis, suggesting that ASD participant's tendency for inflexibly sticking to a rule once it had been implemented may be a reflection of their tendency to *systemize*.

In addition to studies concerning the prisoner's dilemma paradigm, social decision making has also been examined in two studies using the Dictator game. Izuma et al., (2011) asked participants whether they wanted to donate part of a financial endowment or none to a charity, once in the presence of an unknown witness and once alone. The results showed that in the presence of others, TDs but not ASD donated more and responded faster than in the alone condition. In Cage et al. (2013) instead, participants were presented with a series of dictator choices but asked whether they were willing to lose some money so that a charity or a person (reciprocity condition) could gain some money. Unlike TD participants, ASD were not affected by the observer effect when making donations in the charity condition. However, when motivated by reciprocal behaviour in the receiver i.e. interacting with a person, no differences were observed between TD and ASD groups. Together these two studies demonstrate that the decisions autistic individuals make are less affected by the effect of an observer and in none of the groups were the decisions made by participants predicted by ToM levels.

Additional studies examining social decision making have used the Stag-Hunt (Skyrms, 2003), the Trust Game (J. Berg, Dickhaut, & McCabe, 1995) and the Beauty Contest (Nagel, 1995) paradigms. In the former, Yoshida et al., (2010, 2008) asked ASD and TD participants to take part in a computerized version of the Stag Hunt. In its narrative form, two hunters have to decide independently whether to go to hunt a stag or a hare. A stag is the preferable option, however both hunters are needed in order to catch a stag, whereas a hunter can capture a hare alone. Thus, hunters face a dilemma: choose to hunt the stag, but risk catching nothing if the other hunter does not also choose to hunt the stag, or hunt the hare, and settle for a smaller reward. As such, the stag hunt is similar to the prisoner's dilemma. Yoshida et al., used a multistep spatial hunt which finished when a prey was caught. Over the course of the multistep hunt, the computerized agent switched strategy unexpectedly, thus requiring the participant to adjust their strategy continuously and behave optimally in response to the change. The results showed that although ASD participants demonstrated intact understanding of the task, they did not show as strong an ability to adjust to the other player's strategy. Performance showed difficulties in cognitive flexibility as ASD participants relied more on a fixed strategy even if the strategy had already proven to be unsuccessful. However, ASD and TD had similar reaction times, ended the task with similar profits, and had similar cooperation rates.

In another game theoretical study that compared choices of ASD and comparison participants Chiu et al., (2008a, 2008b) investigated the brain mechanisms underlying social decision making during a Trust Game, also known as the investor game. In its basic form, one player ("Investor") is endowed with a certain amount (usually money with adults) and chooses to send some portion of the endowment to the other player, the "Trustee". This chosen amount is tripled on its way to the Trustee, and the Trustee then decides what fraction of the tripled amount to repay to the Investor. This pay-repay cycle and the two decisions within it (invest, repay) constitute a round of play. The basic exchange is repeated within the interacting partners

for a number of rounds. The amount of money invested is a measure of the trust the investor has on the other but also carries the message; “trust me since, I trust you”. There were no differences between the choices made by the ASD and comparison group. However, in the ASD group no increased brain activity was seen in the mid cingulate cortex, an area related to self-reflecting in social situations, which suggest that ASD participants were less aware of the effect of their investment in the Trustee’s eyes. The authors argued that lower activation in this area reflect a diminished ability in ASD to simulate their reputation in the eyes of others. However, these results again indicate that behaviourally, the choices made by ASD and control participants are very similar.

Pantelis & Kennedy (2017) implemented a Beauty contest game in which participants (Adults ASD & TD) were asked to simultaneously choose a number between 0 and 100. The mean of all choices for the given round is calculated, the only winner in that round is the decision-maker whose number is closest to a target number which is announced at the beginning of the game. The winner in this game is the player who chooses a number which represent $\frac{2}{3}$ of the average of all numbers chosen by all players which were in total 250 students. Apart from the obvious arithmetic competence to make the calculation, the game requires players to acknowledge that whatever reasoning strategy they follow, is likely to be followed by other players, thus decision behaviour in this game relies on components of theory of mind. There were no differences in the mean response between the two groups, suggesting that ASD participants used as much strategic reasoning as TDs.

Summary

The literature reviewed in this section suggests that the performance of ASD and TD participants is overall fairly similar across a number of game-theoretical decision-making tasks. However, ASD participants appear less affected by the presence of observers (Chiu et al., 2008a, 2008b; Izuma et al., 2011), unless the interaction overtly suggests the possibility for reciprocation (Cage et al., 2013) and whilst they often respond with similar speeds in game-theoretical tasks, and show similar patterns of cooperative behaviour as TD participants (Yoshida et al., 2008), different brain mechanisms seems to be involved when ASD individuals make decisions that involve others (Chiu et al., 2008; Frith & Frith, 2008b). Although theory of mind processes might be expected to be a source of group differences in social-decision making in ASD, several studies find that theory of mind levels do not predict decision behaviour in interactive games (e.g., Cage et al., 2013; Pantelis & Kennedy, 2017). In terms of results from other non-social decision making tasks, results show that ASD participants are less responsive to contextual manipulations, applying more consist decision making strategies across different experimental conditions instead (De Martino et al., 2008). Finally, studies also suggest less reliance on intuitive and more on deliberative thinking styles (Brosnan et al., 2016). Table 1.1 provides an overview of some of the key existing decision-making studies in ASD, that have shaped our understanding of social and general decision making. These represent some of the crucial studies that motivate an investigation into decision making in ASD, and I will return to them throughout this thesis since a number of features of this literature are worth highlighting in relation to their effects in social decision making and autism.

1.3 Ultimatum Game

As the previous section illustrates, game theoretical decision-making paradigms are very informative about the processes involved in social decision making and a small number of studies have taken advantage of this to shed light on the social interaction difficulties that characterise ASD. The current thesis builds on this existing literature by examining social decision making in autism specifically in the context of the Ultimatum Game (UG; Güth et al., 1982). The UG resembles a social interaction in the form of a simple economic exchange. In the standard UG, a One-shot, two-stage game⁶, two players are endowed with a certain amount of money (i.e. the Pot). In stage one, one of the players, who is designated *the proposer*, is asked to decide how to split the money between himself and the other player, who is designated *the responder* and who usually remains entirely unknown to the proposer. The responder is informed of the split that the proposer has made and chooses whether to accept it or to reject it. If the responder accepts the offer, the money is split as stated by the proposer. However, if the responder rejects, neither of the players gets any money.

In scenarios such as the UG, where power is asymmetrically distributed between players, non-cooperative and self-interested models of social exchange would assume that both players would try to get the best possible outcome for themselves. If both players in the UG also assume that the other player will seek to maximise the income for themselves, the proposer's best strategy would be to offer the minimum positive amount in the knowledge that the responder will accept given that any offer is better than receiving nothing (Ingolf Stahl, 1972; Rubinstein, 1982a). Thus, if the game is played with a £10 pot, self-interested economic theories predict that the proposer⁷, should offer a £9:£1 split meaning that the proposer received

⁶ It is called One - shot because the players only interact once; and it is two stages because there are two decision moments in the game: stage 1 (the proposer decide how to split the money) stage 2 (the responder decide how to respond to the offer made by the proposer in stage 1)

⁷ In the UG literature it is customary that the first number refers to the amount the proposer seeks to keep for themselves, whereas the second number refers to the amount that is offered to the responder.

£9 and the responder £1, because the responder will accept £1 instead of giving this offer up and receive nothing. However, ever since the UG was first tested by Güth et al., (1982) these predictions have been consistently violated across laboratory and field experiments and across different participant groups and societies. Instead, in most cases, about 50 percent of players choose an egalitarian decision strategy; Proposers generally tend to offer between 40 and 50% of the endowment and responders typically reject offers of less than 30% of the total pot. Offers lower than 20% are rare and almost always rejected; conversely, occasionally (although not very often) proposers even offer amounts higher than 50% of the pot. These are commonly known as hyper-fair offers, which are not often rejected, although this does also happen (for reviews of the UG literature see Camerer, 2003c; Güth & Kocher, 2014; Kahneman, Knetsch, & Thaler, 1986a; Debove et al 2016).

These consistent non-normative behavioural findings on the UG, which go against the canonical predictions of self-interested maximization, have stimulated research across different disciplines to identify the conditions needed to promote fairness among individuals, and to understand the situational factors and psychological mechanisms that lead to the acceptance or rejection in ultimatum game-like scenarios. The sections that follow will provide an overview of this literature, starting first with a description of the effects on decision behaviour of manipulations to the structure of the UG, followed by a consideration of the role of individual differences in decision behaviour.

Structural manipulations of the UG

The UG has been administered in a variety of different formats and with different instructions and broadly speaking decision behaviour seems robustly guided by a tendency to offer fair amounts and to reject unfair offers. When effects are observed as a result of experimental manipulations, it often appears to confirm that participants in the UG are

motivated more by the adherence to pro-social norms and consideration of others than by self-interested strategies to maximise personal gain. For instance, there are two commonly used procedures by which participants are asked to make their decisions in an UG: *the strategy method (SD)* and *the direct method (DM)* (Brandts & Charness, 2011; Oxoby & McLeish, 2004). In the strategy method, proposers and responders are asked to make their decisions simultaneously. Under this procedure, players are not assigned a specific role to play in the game but are instead prompted to indicate the offer(s) they would make if they happened to be allocated to the role of proposer, and to indicate whether they would be willing to accept each possible offer if they happen to be assigned the role of responder. In the direct method, by contrast, participants make decisions knowing their role, thereby knowing that responders will only decide when the offer from the proposer is disclosed to them. Initially, some evidence suggested that the *strategy method* might lead proposers to make more unfair offers, and responders to accept more unfair offers than the *direct method*.

Gehrig et al., (2007), for example, invited participants to choose from a set of 20 possible splits, an offer to be passed to a responder, whilst being informed that responders were simultaneously making their decision on how they would respond to each possible offer. The results showed that proposers made more unfair offers and responders accepted more unfair offers than that which would be expected in the direct method, leading the authors to conclude that in situations in which the participants are uncertain about the decisions of the other players, a self-interested maximizing strategy prevails, whereby proposers are more likely to make unfair offers, and responders are more likely to accept all offers. Weber, Camerer and Knez (2004) reported similar findings but argued that the need to make multiple responses in short succession might be the reason why participants adopt the self-interested strategy of offering the least amount possible but also accepting any amount offered. Presumably the strategy

method minimises social considerations and makes the game more abstract, and any unfair offers less visceral and personal.

Despite early suggestions of differences across the strategy and direct method, subsequent reviews of the literature indicated that findings were rather inconsistent and the two methods often lead to overall similar offers (i.e. 40 - 50 percent of the pot) and rates of rejection (Brandts & Charness, 2011). The current thesis will primarily make use of the direct method for examining decision behaviour on the UG in ASD because the role of social-cognitive and social-emotional processes is of prime interest in this context.

Another task-related factor that has received attention in the UG literature is the amount of information participants are given about the other players involved in the UG scenario. Typically, the UG is played without providing the players with any information about the other player involved, under the assumption that providing such information may bias decision behaviour (Charness & Gneezy, 2008). In fact, providing certain kinds of information tends to have fairly strong effects on the decisions of both proposers and responders. For instance, providing information that gives clues about the socio-economic status of players systematically alters decision behaviour whereby unfair offers from seemingly poorer and/or disadvantaged proposers tend to be accepted more often than unfair offers from seemingly rich proposers, and offers to the former tend to be higher than offers to the latter kinship (MacFarlan & Quinlan, 2008). Similarly, as stated by Charness and Gneezy (2008), information about the character of other players (e.g., whether they tend to be kind or mean) tends to affect decision behaviour toward them with negative trait attributes leading to lower offers and greater levels of rejections of unfair offers, whilst positive attributes tend to lead proposers to offer more and responders to accept less. These effects have been explained by the fact that information about the players such as this provides a context within which to understand the motivations of the other players behaviour.

In addition to the effects of providing specific character attributes about players in social-decision making paradigms, some studies have also looked at the effects of player anonymity. For instance, (Charness & Gneezy, 2008) explored how UG behaviour might be affected by providing participants with some minimal knowledge about the other players involved. In a 2 x 2 design, they had 60 students playing either the UG or the Dictator Game whilst having (or not) information about the other player's family name. Both games were played in their standard one-shot form, i.e. one interaction⁸. Results indicated that names had a significant effect on the Dictator Game behaviour but not on the UG behaviour. Specifically, in the dictator game, offers were significantly more generous in the name condition than in the no name condition, whereas in the UG participants made the standard offer for this game (50:50) and rejected offers below 30 percent in both conditions. The increased offers in the name condition in the Dictator Game, suggests that a lack of anonymity promotes more pro-social attitudes and decision behaviours, possibly by reminding participants of the social norms that might typically guide their behaviours. The fact that UG decisions were not affected by the anonymity manipulation suggests that pro-social motives might play a more significant role in this compared to the dictator game by virtue of the fact that responders can influence the outcome of the proposer's decisions. Proposers, in this context, need no reminder of the social norms that guide their behaviour because the nature of the task, with a clearly defined role of responders, might serve that function. And responders might not alter their decisions when given names of the proposer because they are also naturally guided by motives to safeguard social norms and fairness.

Additional evidence for the role of prosocial attitudes in UG decision behaviour stems from studies that have manipulated the extent to which a participant's behaviour remains

⁸ To recall, the Dictator game (Kahneman et al., 1986) is structurally similar to the ultimatum game, in that one player is given a sum of money to split between themselves and a second player. However, in this case, the second player has no recourse – they must accept the split.

anonymous, rather than manipulating the amount of information that is available to them about other players. For instance, evidence from repeated games, where participants interact more than once, suggests that participants guard their reputation by adhering more closely to prosocial values and norms of fairness than in one-shot games (Nowak, Page, & Sigmund, 2000). Conversely, other data show that in contexts where there is a high degree of anonymity for players (e.g. Games over the internet where people do not know other's player name, how they are or how they look like) proposers make significantly smaller offers than is typically the case (Hoffman, McCabe, & Smith, 1996). However when anonymity is low, such as in iterated games in which a player's previous decisions become shared knowledge, fair offers are not only the norm but unfair behaviour is more readily punished with rejection than is normally the case (Fehr & Gächter, 2002). Perhaps the clearest indication that decision behaviour (and in particular the urge to reject unfair offers) is motivated by pro-social values stems from studies which show that responders in the UG, and in other game theoretical scenarios are not only willing to forgo personal gain in order to punish unfair behaviours, they are even willing to incur a cost for discouraging unfairness (Andreoni & Miller, 2002; Fehr & Gächter, 2002; Gintis et al., 2003).

The final task manipulation to be considered in this section, which also lends support to the notion that pro-social values play a significant role in decision behaviour in the UG, is the manipulation of the size of the pot and the nature in which it is presented to participants. Such manipulations are of interest because such manipulations either change the stakes of the game (proposers and responders could potentially forgo a large sum of potential earnings) or the sense of entitlement players feel for a certain share of the money, e.g. Different appreciation might be given to money people have worked for compared to money they happen to find. It is noteworthy that this attitude towards unexpected money may be culture-dependant. Manipulations of this kind therefore provide an interesting way to pitch self-interested

strategies against more pro-social values (e.g., how much money would you be willing to forgo in order to punish unfair behaviour; and how much of a pot you feel entitled to would you give up).

Hoffman et al., (1996) compared the decision behaviour of 96 university students in two conditions with a different pot size of either \$10 vs \$100. Additionally, in half of the participant pairs (48 participants) proposer and responder roles were arbitrarily assigned by the experimenter (the random condition), whereas for the other half of participants the game was framed as a selling/buyer scenario (the entitlement condition), in which participants' allocation to proposer or responder role was ostensibly on the basis of how well they scored in a general knowledge test. Results showed that in the random condition there was no significant difference in the distribution of proportional offers as a function of pot size, but rejection rates were higher in the \$10 condition than the \$100 condition. However, in the entitlement condition, the pot size modulated both proposer and responder behaviour. On average proposers offered less, and rejection rate was lower than in the random condition. Rejection rate in the smaller pot was interpreted by the authors as a sign of "respect" towards the proposer earned entitlement. Whereas, rejection rate when the pot was \$100 was perhaps "a sign of reduced sympathy" towards a greedy proposer. All in all, the results suggest that individuals engage more self-interested strategies as the pot increase and this effect is even more pronounced when they feel entitled to the pot.

To further this line of research, Andersen et al. (2011) examined the effects of a pot-size manipulation in an ecologically very valid context. Specifically, they carried out a study in an Indian village that was economically relatively deprived, using the local currency (Rupee) to create four pot types. The smallest pot was the equivalent to less than an hour of work whereas the largest pot was equivalent to half a year of salary (in dollars \$0.41, \$4.1, \$41, and \$410). Participants (n=916) were randomly assigned to the role of proposer or responder in

each of the four pot-size conditions. The median offer was only 20% of the pot, which is a considerably lower percentage than the 50% to 40% commonly found in previous UG pot (Camerer, 2003c; Güth & Kocher, 2014; Kahneman, Knetsch, & Thaler, 1986a). More importantly, there was an increase in the percentage offered as the size of the stake increased, suggesting that proposers may be less willing to risk losing high values due to rejections by the proposer. Similarly, an inverse relation between pot-size and rejection rates (i.e. rejection rate in the smallest pot was higher than rejection rate in the largest pot) suggests that in the role of responder participants were less willing to sacrifice large amounts of potential earnings to punish unfair behaviour. These findings suggest that – for responders at least – with sufficiently high stakes, self-interested motives start to dominate an otherwise very robust tendency to behave pro-socially in the UG.

Another group of researchers, exploring the effect of pot size in UG-decision behaviour changed the pot altogether, and instead of money used time as currency. Berger et al. (2010) reasoned that in the standard UG, participants may feel that they should behave fairly because the pot of money they make their decisions over is provided by the experimenter and therefore any decision does not incur any real cost to the participant (Burger, 2009). To overcome this potential bias, Berger et al., (2010) used time instead as the value to decide over. Time is not provided by the experimenter but represents a natural ‘resource’ that people typically value and do not want to give up unless for good reason. Berger et al. expected, therefore, that compared to monetary stakes, offers of time would be less generous and rejection rates lower. In the experiment, participants were asked to bargain anonymously over waiting time to collect their fees for having participated in some experiments. The proposer was asked to split 60 minutes of waiting time with another randomly assigned partner with the typical instruction that the responder could either accept or reject and therefore affect whether both partners would wait for the proposed amounts of time (if accepted) or each have to wait 60 minutes (if rejected).

The modal offer was thirty minutes, and only one offer was rejected: the split suggested the responder to wait 40' and the proposer 20'. Contrary to the standard rational prediction, the results suggested that participants in this variant of the UG behaved just as fairly as is the case in the typical UG scenario, suggesting that even when decisions incur certain costs, pro-social attitudes or value appear to dictate that such costs should be shared equally.

Overall, the evidence outlined in this section suggests that decision behaviour in the UG is fairly robust across different implementations of the basic paradigm. Irrespective of whether proposers and responders make their decisions simultaneously or successively, whether the game is played for real or hypothetically, whether the pot size is small, moderate or large and whether there are costs involved in taking one decision over another, participants reliably behave irrationally in a purely monetary sense, upholding and protecting social values of fairness and equity over attempting to maximise personal gains. That said, structural variations in experimental design can influence the extent to which people relatively weight fairness and monetary gain considerations.

In addition to structural elements, there are also considerable individual differences in UG behaviour, which have attracted considerable interest as a source of information about what psychological factors contribute to other-regarding preferences vs. more self-interested social-decision making. These will now be discussed.

Cultural and individual differences

A number of studies have examined the influence of cultural factors on UG behaviour, to determine whether the values that appear to motivate fair decisions in this paradigm are universally upheld and, if not, understand what societal and cultural factors might make people behave in more self-interested ways. In a large cross-cultural study (Henrich et al., 2001) examined whether UG behaviour was affected by the survival practices (nomadic, subsistence

agriculture and sedentary agriculture practices) of participants from 15 small -scale societies in 12 countries from different parts of the world. The pot size was the equivalent to two days' salary, and the currency used was chosen based on the community's trading customs, either their local money or goods. The findings from proposers showed that mean offers ranged from 26 to 58%, which represented a larger range than that observed in industrialized societies (between 44 and 50%). Similarly, the acceptance threshold was 16% rather than the 30-40% that is typically observed (Camerer, 2003c; Güth & Kocher, 2014; Daniel Kahneman, Knetsch, & Thaler, 1986a) and hyper-fair offers were often rejected. In none of the groups the *homo economicus* maximizing behaviour was observed that would lead to minimal offers that would often be accepted. However, the wide range of offers and lower threshold for acceptances suggests that trading and social norms within the community may influence the extent to which social-decision making is driven by pro-social vs. more self-interested motives.

A few years later, Güth, Schmidt and Sutter (2003) examined whether academic level would impact UG decisions, based on the assumption that non-academic participants would rely more on social norms of fairness when making their decisions, whereas academics will rely more in rational game theory models, the issue was examined by implementing an online experiment. The authors used a novel approach to create a diverse pool of participants (diversity in academic background, age, gender and geographical origin) by inviting student and non-student readers of the Berliner Zeitung from both Berlin and Innsbruck to play an UG. This newspaper was selected as readers were known for not having a high academic background. Participants were asked to play both roles as proposers and responders over 10 independent trials that added up to a total pot value of 1000 Deutsche Mark (around £600) - one of the largest pot sizes to be examined in the literature. Payment of participants was supported by the newspaper. Decisions were paid to three pairs randomly chosen and according to their decisions. Geographic origin of the participants had no effect on decision behaviour. The split

mode was half of the pot (DM-500) and acceptance rate increased as the offer increased. Against the prediction, strategic fairness was suggested to have motivated decision behaviour similarly in this pool of participants. Against the prediction, levels of education did not differentiate between those with self-interested and prosocial preferences. Interestingly, comparing responses by medium, i.e. those who submitted their responses via email, fax or post, it was reported that responder using email were more likely to make decision based in self-interested motives than those who submit their responses by fax or via post. Since internet is more commonly used by young readers who in addition are likely to be within the education system, the results were used to partially support the initial hypothesis.

The two studies by Henrich et al., (2001) and Güth, Schmidt and Sutter (2003) are among the representative studies that have examined cultural and educational influences over UG decision making, suggest that learning, cultural shared value and rules of social exchange that apply in day-to-day life influence UG behaviour at different levels. In his review Henrich et al., (2005) suggested that prosocial behaviour increases with market integration and relates to the value assigned to cooperation in daily life.

In addition to the broad cultural factors that have been found to affect social decision making in the UG and other game-theoretical paradigms, a number of individual characteristics have also been found to play a role, including a person's ethical dispositions and concerns for equity, and also their analytical skills and attitudes towards risk (Brandstätter & Güth, 2002). Since many of the characteristics that are suspected to play a role in determining decision behaviour in the UG are also known to vary systematically across gender, for example, it is interesting that some gender differences do, indeed, exist in UG behaviour. Specifically, whereas proposer behaviour does not differ systematically between men and women (Eckel & Grossman, 2001; Solnick, 2001), as responders women tend to reject significantly more unfair offers than men do (Solnick, 2001). Furthermore, both Eckel and Grossman (2008) and Croson

and Buchan (1999) found that men and women behave similar in environments not involving risk, as the UG, meaning that as responders players may have other reason to accept/ reject than the one given by default in nature in the form of gender. Despite the mixed results in regards to the effect of gender in the UG behaviour, the existing results are worth mentioning given the extreme male brain theory of autism (Baron-Cohen, 2002). This theory suggests that ASD behaviour represents an extreme version of typical male behaviour relative to female behaviour. Thus, if men accept more unfair offers than women, then ASD participants might be expected to accept even more than male or female neurotypical controls.

Although in the UG players know in advance the consequence of their decisions, García-Gallego et al. (2012) found that aspects of risk aversion explain decision behaviour in an UG framed as an interaction between employer and employee. The risks involved in the UG are very different for the proposer and responder roles, since the responder faces a completely risk-free decision, whereas the proposer faces the risk of having their offer rejected. Thus, attitudes toward risk (e.g., risk aversion) should play less of a role for responder than proposer behaviour. García-Gallego et al., (2012) confirmed this prediction by showing that risk-averse individuals tended to make higher offers than non-risk averse individuals, whilst no such association was found in relation to responder behaviour.

In relation to ASD, studies suggest that autistic individuals tend to be generally more risk averse, possibly as a result of increased levels of anxiety and the associated ‘fear of failure’. For instance South et al. (2011) used a version of the Balloon Analogue Risk Task, in which participants (ASD & TD) were asked to “pump” a virtual balloon without reaching the explosion point, which varied randomly across balloons. The two groups did not differ in the number of risky pumps per trial, and both groups showed similar skin conductance level. However, it was found that the frequent anxiety in the cognitive profile of ASD correlate with risk taking and an increased motivation to avoid failure and punishment as measured by the

BIS component of the BIS/BAS scale (Carver & White, 1994). Further evidence by (Bejerot, Eriksson, & Mörtberg, 2014; Robertson et al., 2018) confirmed that anxiety is a recurrent issue for ASD. Taken together this evidence suggest that as proposers, autistic individuals are likely to make egalitarian offers during the UG. As responders the evidence is less clear. The stronger emotional reactivity in anxious individuals may lead individuals to have oversensitive reactions to inequitable UG- offers and reject more often (Grecucci et al., 2013), however high anxiety could also increase acceptances rates to avoid confrontation (Mennin, Heimberg, Turk, & Fresco, 2002).

Among the most important factors thought to contribute to individual differences in social-decision making, and one that is related to the concept of risk aversion, is the sensitivity of individuals to the emotional salience of events. There is a growing consensus in the social-decision making literature (and the decision making literature more generally) that humans deviate from the rationality predicted by normative laws of social exchange (Simon, 1986) because of the emotional salience of different decisions and their consequences (Loewenstein, 2000; Loewenstein & Lerner, 2003; Rick & Loewenstein, 2008). Processing of emotion-related information is crucial for goal attainment and for social exchange, for instance when forming mental models about other's intentions and goals (Fessler, 2007; Singer et al., 2005). Emotions have been reported to shape behaviour (Damasio, 1994) and guide decision making (Haidt, 2001; Rilling & Sanfey, 2011) and impairments in emotion-related processing due to brain injury increases risk taking (Bechara, Damasio, & Damasio, 2000). Critically, studies have shown that participants' decisions tend to be guided by physiological markers (so-called somatic markers) that are argued to represent the emotional salience of the different decks in a decision-making task and these Somatic Markers tend to guide decision behaviour before participants can explicitly reason about what motivates their decisions (Bechara et al., 1997).

Much of the research underlying the somatic marker hypothesis has used the Iowa Gambling Task. This task requires participants to choose cards from one of four decks with the aim to win as much money (or as many points) as possible. Each choice leads, probabilistically, to certain amounts of winnings and losses. Some decks yield on average greater wins than losses, whilst the other decks are disadvantageous. Neurotypical participants generally learn to choose advantageous decks (Bechara et al., 1997). However, with lesions in the ventro-medial prefrontal cortex (vmPFC), who have relatively intact cognition but struggle with emotional processing, tend to continue to choose the disadvantageous decks. Furthermore, unlike controls, vmPFC patients did not show anticipatory changes to skin conductance response before choosing from disadvantageous decks, suggesting that they did not have the same automatic emotional response to available options that could guide decision making (Bechara et al., 1997; Bechara & Damasio, 2005). These results have implications for UG behaviour because studies by Sanfey et al., (2003) and Van't Wout et al., (2006) suggest that somatic markers also guide responder behaviour with increased arousal typically associated with higher rates of rejection. I will come back to this topic in chapter 3.

Another factor that has been the focus of interest in the context of the social decision-making literature is the role of cognitive style. According to several authors (Evans & Frankish, 2012; Daniel Kahneman & Frederick, 2002; Keren & Schul, 2009; Kruglanski & Gigerenzer, 2011) while some people tend to make choices primarily on the basis of intuition, others tend to rely on more controlled reasoning, which have respectively been referred to as System 1 and System 2 modes of information processing. System 1 is thought to process information fast, automatically and based on heuristics and operate independent of general intelligence and working memory abilities, whereas system 2 is regarded as slow, deliberate and analytical, depending on general intelligence and working memory. Previous studies have examined System 1 and 2 through the CRT task (3i-CRT: Frederick, 2005). In addition to play as

responder in a UG, participants were asked by Calvillo et al., (2015) and De Neys et al., (2011) to complete the cognitive reflection task (3i-CRT: Frederick, 2005). The test, fully described in Chapter 3, is a behavioural task to measure difference an individual's tendency to over-ride an intuitive response and engage in a deliberative reasoning style. As noted briefly above, in the task, participants are presented with a number of mathematical problems which have two responses: an apparent correct answer, labelled in this context, intuitive; and a correct response to which people arrive by deliberation. Accordingly, individuals come up with correct responses after successfully suppressing intuitive answers. Accuracy in the 3i-CRT was found to predict acceptances of unfair offers. As noted earlier, evidence in relation to ASD suggests better performance on the CRT (e.g., Brosnan et al., (2016a) suggesting that ASD might be characterised by a greater tendency to accept unfair offers.

The final individual difference factor that is worth pointing out is the role of sex hormones in UG decision behaviour, most notably testosterone and oxytocin. These hormones have started to get the attention of decision making researchers since levels of such hormones have been found to be relevant for the study of preference building and social status. From an adaptive perspective to explain human behaviour, it has been shown that high testosterone individuals are more willing to engage in conflict whereby this kind behaviour operates as reputation management mechanism to establish a position within the social hierarchy (Book, Starzyk, & Quinsey, 2001). In the UG, for instance, rejection is considered a form of punishment that serves as a psychological mechanism to subordinate group members that represent danger to the punisher or to the status of the wider community (Clutton-Brock & Parker, 1995). Burnham (2007), asked twenty-six male adults to play as proposers and responders in one-shot UG with a \$40 pot, giving participants the option as proposers to only choose either \$5 or \$25 offers out of \$40. Testosterone measures were taken from saliva before and on the day of the experiment. Results showed a significant correlation between high

testosterone levels and high rejection rate of the unfair offers. Zak et al., (2009) extended these findings to proposer behaviour using an experimental rather than correlational procedure. The study was also done with a male pool of participants who received artificial testosterone, applied in the form of gel and spread in their shoulder and upper back. Compared to participants who received the placebo, testosterone receivers showed reduced generosity of the offers by 27% and this participant also reject more unfair offers.

Turning to the effects of oxytocin, a hormone associated with generosity and empathy evidence is given by the same group of researchers (Zak, Stanton, & Ahmadi, 2007) who tested the effect of oxytocin in decision behaviour. Oxytocin was administrated to male participants through intranasal infusion. As proposer, oxytocin's receivers were 80% more generous than participants on placebo. However, no effect was observed in responder behaviour. As concluded by the authors themselves, the effect of testosterone and oxytocin in UG decision behaviour is still speculative and more evidence is needed. More generally, there is evidence suggesting that high testosterone hinders oxytocin receptors binding, and this effect becomes of particular interest to this research project. According to the E-S theory of autism (Baron-Cohen, 2002) high testosterone is associated with autism and since testosterone levels hinder oxytocin binding, lower levels of empathy are expected in this group, which will be then associated with less generous offers when playing as proposers. On the other hand, in the general population testosterone seems to play a more central role in male behaviour than in female behaviour, therefore this effect may be heightened by autism, resulting in higher rejection rate of unfair in the ASD group.

Summary

This chapter has provided an overview of the main clinical and associated cognitive characteristics of Autism Spectrum Disorder, highlighting that ASD is primarily a disorder of

social-communication and social affective behaviours that is thought to be the consequence of a combination of developmental differences in low-level perceptual and higher-level cognitive domains. Many of these differences – in Theory of Mind, Social-emotional processes, Executive Functions and the balance between a tendency to systemize vs. empathize – all appear relevant to how individuals make decisions in social encounters. The second section of this literature review, therefore outlined research on the UG in the general population. The UG is a simple and interesting game-theoretical paradigm for examining a whole variety of decision making strategies and motivations – including economic rationality, fairness, reciprocity, insight into the strategies of others. Unlike individual decision-making tasks, the UG requires from participants the ability to understand the broader social context in which decisions need to be made and research on this paradigm highlights that many of the processes that appear to guide decisions are those that tend to be implicated in the cognitive phenotype of ASD. The aim of the work presented in the following chapters, therefore, is to scrutinize social-decision making in ASD on variants of the UG to establish to what extent ASD is characterised by atypicalities in the social-decision making domain. In the first study, presented in Chapter 2, decision behaviour is examined in the most basic version the One-shot UG and a number of individual difference factors are examined (e.g., Theory of Mind) to establish what predicts certain decisions in ASD vs. TD participants. In the second study, the role of emotions in UG responder behaviour is then assessed in more detail in a multi-trial UG that permits the examination of emotional responses using GSR, as participants decide over offers presented by human vs computer proposers. In Chapter 4, information processing styles are probed by imposing a time pressure manipulation while participants responded to different fair and unfair offers of a UG and the Cognitive reflection task was also used to quantify System 1 vs. System 2 processing styles. Finally, in the fourth study set out in Chapter 5 a modified version of the standard UG is implemented, known as the mini-ultimatum game, which provides insight in to

the extent to which responders consider the intentions of offers from proposers (rather than the absolute value of the proposed amounts).

2 EXPERIMENT 1: ONE SHOT ULTIMATUM GAME

The last few decades have seen an increasing interest in understanding the impact of social cognitive processes on the decisions people make in social interactions. Contrary to a classic assumption in economic exchange, which suggests that out of rationality people are self-interested and material-maximisers, it is now largely agreed that our preferences reflect not just the material outcomes, but other wider social cognitive considerations such as preferences for reciprocity, fairness, and the consideration of how a particular choice will be perceived by others. The ultimatum game (UG), outlined in the previous chapter, is amongst the most widely used paradigms to illustrate how prosocial motives can lead to violations of economic rationality (Güth et al., 1982).

Briefly, to reiterate, in the UG a proposer decides how to divide a given amount of money between themselves and a responder, who can either accept or reject the proposal. If the responder accepts, the money is distributed as the proposer suggests, but if the responder rejects then neither player receives anything. Rational theories of economic behaviour predict that proposers will offer the lowest positive amount of the total pot possible since a rational responder should accept any amount above zero (Rubinstein, 1982b; Von Neumann & Morgenstern, 1944). However, contrary to this prediction, results from the UG consistently show that neither the proposer nor the responder conform to the expectation that people behave to individually maximize their gains. Instead, the modal offer proposers normally make is 50% of the total pot, and at least half of responders reject offers below 25 - 30% of the stake (Camerer & Thaler, 1995; Güth et al., 1982; Rubinstein, 1982b).

As outlined in chapter 1, a number of social-cognitive and social affective processes have been identified as likely contributors to the systematic violations of economic rationality on the UG. These processes include those that are reliably implicated in the clinical and/or

broader cognitive characterisation of ASD, such as understanding other people's intentions (ToM: Theory of mind) and emotions (Empathizing) and the drive to understand the logical rules that govern cause and effect relations (Systemizing). And processes about which less is still known in the context of ASD, such as the balance between the behavioural activation (BAS) and behavioural inhibition (BIS) systems, which guide the seeking of rewards versus the avoiding of risk and losses respectively. The following sections will examine these processes again in more detail to derive predictions about how autistic adults might behave as proposers and responders in the UG paradigm.

Theory of mind: Given the nature of the UG paradigm, it is relatively uncontroversial to suggest that the ability to anticipate other's actions in terms of their thoughts and desires should play an important role in guiding decision behaviour. Yet, experimentally, it is not easy to demonstrate the role that ToM plays in this context. One approach that illustrates the role of ToM indirectly, and which will be the focus of the next chapter, is to compare UG-decision behaviour between conditions where either a human generates offers or offers are generated randomly by a computer or a roulette wheel. Such studies show greater rejection rates of unfair offers from a human than a computer proposer (Blount, 1995; Van't Wout et al, 2006), arguably, because participants base their responder decisions, at least in part, on considerations about the intentions that motivated unfair proposals. Other evidence stems from brain imaging studies that indicate that brain regions typically associated with ToM functions are activated during the UG (Rilling et al., 2004). Most relevant to the current chapter, however, are studies that seek to examine the role of ToM more directly, either by comparing decision behaviour between groups of participants who differ with respect to their ToM abilities, or by examining associations between decision on the UG and performance on tasks that are considered to provide a valid measure of ToM ability.

In typical development, ToM abilities are thought to first emerge at age of around 4 years, at which point most children pass standard 1st order standard false belief tasks, such as the Sally-Anne test described in Chapter 1 – in other words, they understand that someone else can hold beliefs that differ from reality and/or their own beliefs. By age 6-7 years, most typically developing children also begin to understand 2nd order belief situations (e.g., John thinks that Mary thinks that it is raining) and continue to grow in parallel with the development of executive functions, specifically those concerned with inhibitory control (Dumontheil, Apperly, & Blakemore, 2010; Im-Bolter, Agostino, & Owens-Jaffray, 2016). In the context of this typical trajectory of ToM development, it is interesting that UG behaviour differs between children of different ages. For instance, Harbaugh, Krause and Liday (2003) compared decision behaviour of children under the age of 11 years against the standard reported findings for adult behaviour in the Dictator and Ultimatum Games. Compared to the adult data, the children made smaller offers as proposers, and more often accepted unfair proposals as responders. Güroğlu, Van Den Bos and Crone (2009) extended these findings by comparing 9, 12, 15 and 18-year olds on their proposer and responder behaviour in a mini-UG paradigm. With this design the authors controlled distributive and intentional fairness by limiting the distributional options available to proposers. Proposers had to choose one of two offers, one option was always an unfair 8-2 offer, whilst the other option was either fair (5-5), even more unfair (10 - 0) or hyper-fair (2-8). If participants as responders cared only for distributive fairness, their decision would only depend on the amount they were offered. If they cared about the proposer's intention, they would be expected to reject offers when the proposer had the option of making a fairer offer, but not if the offer was the fairest available to them. Similar to Harbaugh et al., (2003), younger children were less likely to choose the fairest option available to them than the older children with a linear increase in fair decisions across the four age groups. Furthermore, as responder younger children were less sensitive to the options the proposer would have had to choose from

than older children, again with linear changes across ages. Together, these findings suggest that children from age 9 onwards increasingly take into consideration the intentions of others when making decisions in the UG.

Although the studies just mentioned are in line with the suggestion that ToM plays a role in social decision making, they do not directly assess ToM involvement. More direct evidence in this sense, stems from a study by Takagishi and colleagues (2010), who compared UG behaviour between those who pass and those who fail a ToM task. Specifically, sixty-eight typically developing five-and-a-half-year-old children ($M = 65.8$ months; $SD = 7.0$) were invited to take part in a one-shot UG, with the children randomly paired and randomly designated to play either as proposer or responder. The experimenters developed a set-up that allowed children to interact face-to-face while bargaining over ten candies. Children in the proposer role were instructed to choose candies for himself and to leave the remaining candies for their partner in the tray that all candies were initially presented in. Children were told what would happen if the child in the responder role accepted or rejected the candies they were offered – adults who were present during the interaction would either distribute the candies according to the proposal or take them away. Following the UG interaction, all children completed the Sally-Anne task as a measure of ToM (Baron-Cohen et al, 1985). Eighty three percent of children who passed the false belief task made a fair proposal (5 candies to the responder) while only 36% of those who failed to pass the false belief task proposed a fair offer. In the role of responders, children rejected offers that were below 50% (five candies) and this behaviour was unaffected by theory of mind scores.

A few years later the authors replicated and extended these findings to show that cognitive aspects of ToM, rather than emotional aspects appear to contribute to UG decision behaviour in young children (Takagishi et al., 2014). As in their earlier study, the authors compared young children ($M = 56$ months, $SD = 10.0$) who had either passed or failed the Sally-

Anne test on their UG decisions. In addition, however, children in this study also completed an emotional perspective taking task – The Denham task (Denham, 1986) – which required children to label the emotions that would be experienced by characters in short stories. Regression analyses showed that cognitive (i.e., Sally-Anne test) but not emotional (i.e., Denham task) facets of ToM influenced proposer behaviour, with Sally Anne passers making fairer offers than failers, as in the earlier study. Interestingly, responder behaviour was negatively associated with Sally-Anne test performance whereas understanding of emotional states as measured by the affective perspective task was not predictive of UG behaviour.

The authors suggest that participants' familiarity with one another, may be the explanation to the differences observed in the responder behaviour of these two studies. Contrary to the first study (2010) where participants did not know one another, in the latter (2014) all children taking part in the study belonged to the same class. This familiarity may have led those with good cognitive ToM to avoid rejecting unfair offers to elude upsetting the relationships with peers. The responder effect observed here was not observed in the early study therefore further evidence is needed to clarify the role of ToM in responder behaviour.

Given the well-established ToM difficulties associated with ASD, and the evidence just outlined, it follows that autistic individuals should be less likely to make fair offers in an UG than typically developing comparison groups. To examine this issue Sally & Hill, (2006) asked sixty-nine children between 6 and 10 years of age, with and without autism spectrum disorder, to play 16 rounds of a dictator game (DG) and 16 rounds of an UG with the experimenter as the partner. The child and experimenter alternated their roles every 4 rounds and on each round the stake was 10 points (stickers) with the children encouraged to win as many points as possible. During the Dictator Game, participants first played in the role of dictator for four rounds, then observed the decisions of the experimenter for four rounds before acting as Dictator again for four rounds and ending this task one more time observing passively for four

rounds. The experimenter in this task, offered approximately the amounts offered to him when taking the role of Dictator. In the UG the roles alternated in the same manner every four trials with the child beginning as proposer. The confederate, in the role of responder, would always reject offers of less than 40% of the total pot, and as proposer would offer approximately the same amount of points as the child had previously offered.

As proposers in the UG, children with and without ASD, who failed a second order ToM task⁹, offered nothing or only one point out of 10 only on the first trial. From round two and as the game progressed, the difference between passers and those failing the ToM task disappeared for all ASD and TD but not for children below 6 years of age. In this group, the mean offer remained scattered over all the possible options until the end of the game, which according to the authors, may be due to their not yet developed ability to predict consistency in other people's behaviour. DG behaviour further confirmed these results. Comparison between the size of the offers made in the Dictator vs UG games showed that whereas the size of the offer dramatically increased as typically developing children go from dictators to proposers, the change in the size of the offers made by ASD children was almost unnoticeable and not statistically significant. ASD participants stuck to either one of two strategies: offer 1 (maximizing strategy) or 5 stickers (inequity aversion rule). This suggests that while TD children may use their ToM abilities to anticipate reaction to unfair behaviours, ASDs may struggle to adjust their strategy in response to the change in the receiver's role. As responders, children below 6 years of age as well as children with ASD accepted more small offers, and ASDs more often rejected offers that were beneficial to the responder (hyper-fair offers), i.e.

⁹ First-order false belief understanding was assessed in all participants using the Sally–Anne task (Baron-Cohen et al., 1985; Wimmer & Perner, 1983) and second order false belief understanding was assessed using the Birthday Puppy story (Sullivan et al, 1994)

40% for the proposer – 60% for the responder. Thus, reciprocity fairness per se cannot not explain responder behaviour.

A similar trend was observed with an adult sample in a study by the same researchers Sally & Hill (2003, unpublished). Both ASD and TD adults similarly and fairly split the pot in the UG. As responders and compared to children's behaviour in the 2006 study, who accepted offers that represented 23% of the pot, in the current study adults showed a higher acceptance threshold, which lead them to more often reject offers that were below 32% of the total pot. Differences between groups were present only on the first but not for the remaining trials, suggesting that repetition may have introduced some learning effects, which, in the case of the ASD group, may have contributed to compensate for the diminished ToM abilities as reported from the ToM task scores¹⁰.

It is interesting to note that the pattern of results described by Takagishi et al., (2014) on one-shot UG, compared to Sally & Hill's (2006) observations on a multiple trial paradigm, suggests that repetition and reciprocation has an effect in UG-behaviour whereby children learn to adapt to the nature of the interaction, moving toward more equitable and fairer decisions that they may not display in one-shot scenarios. The findings suggest, that one-shot games might be more sensitive to the role of Theory of Mind in decision behaviour, which is why the current study will use such a one-shot paradigm to further extend the findings of Sally & Hill (2003, 2006). More generally, further exploration of the relation between UG decisions and ToM is important considering that the evidence to date is not entirely consistent and still relatively scarce. Given that ToM difficulties are a well-established feature of the social-cognitive characteristics of autism, studying UG decision behaviour in this group can shed new light on the role of ToM in game-theoretical decision making paradigms.

¹⁰ Second order false beliefs task: For adults, the Coat Story (Bowler, 1992)

Systemizing - Empathizing: Whilst the limited number of studies to date, that have examined UG behaviour in ASD have focused on the role of ToM impairments in this social-decision making scenario, no studies to date have formally considered the role of some of the other characteristics of ASD in this context. As noted in Chapter 1 and as suggested by Baron-Cohen *et al.*, (2003), ASD individuals have an increased tendency to process situations in a “systemizing” rather than an “empathizing” way (see also Baron-Cohen, 2009), where systemizing refers to the drive to analyse, understand, predict, control and construct rule-based systems, whereas empathizing refers to the drive to identify another person's emotions and thoughts, and to respond to these with an appropriate emotion. In the context of the UG, it is reasonable to assume that both processes might be engaged to predict the behaviour of others. Empathizing could be involved in terms of attributing our own emotions, goals, values etc. to the other player in the interaction, whereas systemizing could be involved in terms of constructing and applying rules for seeking to predict the other's behaviour and for guiding own decisions. Interesting in this context, is that Sally and Hill (2006) in the study described above, observed that on the multi-trial UG, autistic children more than the comparison group, consistently adhered to a strategy across trials rather than adapting their behaviour to the behaviours of the partner. Specifically, autistic children frequently opted for either a fair strategy throughout all trials or for a ‘keep it all’ strategy, offering the minimum amount possible as proposers and accepting low offers as responders. Assuming that this pattern of behaviour is partly a reflection of the greater tendency to systemize in ASD, it would be expected that a greater tendency to systemize would be related to a greater tendency to adopt a ‘keep it all’ strategy, which would also be in line with rational economic theory – a theory which should provide a logical and systematic description of human social-economic behaviour. In a study by Ramsøy *et al.*, (2015) in which a prisoner dilemma was framed either as cooperate or compete, a relation was found between empathizing and cooperation rates, i.e.

adults participants who scored high in the empathizing measure responded faster and cooperate more, but such an effect was absent when the game was framed as compete. These results although not specifically related to the E-S theory, give support to the same theory's suggestion that individual differences in empathy may reflect the extent to which individuals let such process affect decision-making. Furthermore, in ASD high systemizing / low empathizing biases might make decision makers less sensitive to the social aspects of the interaction (Memari et al., 2015), which could lead decision makers to be less sensitive to the social consequences of their decision, e.g. reject to punish.

BIS/BAS In addition to examining the role of Theory of mind and the balance between systemizing and empathizing on UG decision behaviour, the current study will also examine how individual differences in the behavioural inhibition (BIS) and behavioural activation (BAS) systems might impact decisions on the UG. In the general population, the study of individual differences associated with the behavioural activation system (BAS) and the (BIS) behavioural inhibition system (Carver & White, 1994; Gray, 1994) have been useful to assess individual differences in reward sensitivity; additionally variation in sensitivity of BIS and BAS has been thought to reflect more general individual differences in personality traits associated with social and emotional responding (Franken & Muris, 2006)

BIS is thought to form the basis of anxiety and result in behavioural withdrawal, whereas BAS is considered to mediate reactions to reward (Elliot & Thrash, 2002) and result in behavioural approach and risk taking. An approach bias (BAS) leads the individual to initiate goal-directed activities and interactions and to anticipate positive affective states when exposed to cues of potential reward. On the other hand, a bias toward BIS leads to a tendency to inhibit movement toward goals, to experience negative affective states such as fear and anxiety in response to novel cues, and to withdraw from novel situations and social interactions. In the context of the UG, Scheres & Sanfey (2006) had university students playing as proposer and

responder for real with a \$5 pot. The mode offer was 47% of the pot (\$2.37); offers of \$2 and higher were accepted, whereas offers of £1.33 and under were rejected. After the UG, participants filled the BIS/BAS scales (Carver & White, 1994) mean total scores followed the result patterns of the original sample. Correlation analysis between BAS scores and UG- offers showed a positive association between BAS scores and the offer's size, and this was interpreted as a strategic move to increase the possibility of getting the offers accepted, i.e. the reward.

More recently, Harjunen et al., (2018) invited university students to play an UG interacting with a computerized agent. The authors examined how individual differences in motivational traits modulated proneness to the agent persuasive impact. Participants received offers from agents whose facial expressions portrayed emotions that vary to include neutral, happiness, anger, fear, disgust, surprise, sadness emotions. In addition, the agent was set to apply a touch effect in the responder's hand (The Midas touch effect; Crusco & Wetzel, 1984). High BIS scores were associated with rejection rate of unfair offers presented by an angry face, interestingly the touch effect was not associated with responder behaviour for participants who scored high in BIS. The results suggest that BIS moderated the effect of facial expressions but not touch. Since the meaning of touch is more culturally dependant (Gazzola et al., 2012) than the meaning of facial expression, which have more universally agreed connotations (Elfenbein & Ambady, 2002), the authors concluded that high BIS individuals are more sensitive to cues that clearly convey a negative meaning.

In the context of ASD, there continues to be relatively little systematic research concerning the functional balance between BIS and BAS systems. However, several of the characteristics of ASD can be conceptualised within a BIS/BAS framework. For instance, the social motivation theory outlined in the introduction argues that autistic individuals find social interactions less rewarding (Chevallier, Kohls, Troiani, Brodtkin, & Schultz, 2012b), which would suggest an attenuation of BAS at least in terms of rewards derived from social

interaction. As Gaigg (2012) has argued, however, the evidence in favour of a social-motivation theory may be a reflection of more domain general abnormalities in processing the emotional salience of stimuli (social or non-social), which could result from atypicalities in a domain general BAS system attenuation. In terms of the functions of BIS, it is well known that ASD is commonly associated with symptoms of anxiety and an insistence on sameness (i.e., avoidance of novelty), which implicates augmented activation of the BIS system. South et al. (2011) has furthermore shown that the frequent anxiety symptoms in ASD are also correlated with increased motivation to avoid failure and punishment (BIS) rather than to seek out rewards (BAS), and Mundy et al., (2007) have argued that BIS and BAS function as modifier contributing to explain the variability in ASD social emotional development and reinforcement responsiveness. For instance, high BAS individuals are expected to maintain motivation and to have less difficulty to keep engaged in task and activities; whereas high BIS individuals required more frequent and varied reinforcement mechanisms. All in all, the literature on BIS/BAS suggests that on the UG, ASD participants would accept the unfair split more frequently and as a proposer they will make fair splits as to avoid rejection.

Ethics and moral judgement, in human societies moral and social codes have evolved to regulate social interaction but individuals differ in the extent to which they use moral absolutes as guides to action and judgment hence differences in responses to social dilemmas are observed. Forsyth's Ethics Position Theory (EPQ; Forsyth, 1980) holds that although most people explicitly consider the relative importance of minimizing harmful, injurious consequences, individual moral values and beliefs vary from the idealistic, to the completely pragmatic. *Idealistics* tend to make use of universal moral principles, such as “*Tell the truth to others*” and “*Do unto others as you would have them do unto you,*”. Such principles provide a clear yardstick for judging and guiding actions and idealistic individuals tend to be guided by such principles to make decisions that protect the welfare of others. They also tend to believe

that ethical behaviour will always lead to good outcomes. On the hand, *relativists*, prefer personal and situational analysis of behaviour over universal codes of morality, for instance, harming others can be seen as a good behaviour if the consequences turn out to be beneficial to the decision maker or society more generally. Despite of this conceptual ethical differentiation, an individual profile has a combination of both with a tendency to one or the other.

Some of the characteristics of ASD, such as their tendency for repetitive and routinized patterns of behaviour, difficulty with cognitive flexibility and tendency for systemizing might make them more likely to adopt idealistic rather than relativistic moral rules, placing individuals in the category of absolutism in Forsyth's (1980) taxonomy, in which an individual "assumes that the best possible outcome can be achieved by following universal moral rules" (p.176). Consequently, it might also be predicted that ASD participants' representation of the UG might be more driven by relatively rigid conceptualisations of equity in distribution than more relativistic and flexible trade-offs between personal gain and fairness considerations. This tendency may result in UG decisions motivated by inequity aversion and higher rate rejection of unfair offers.

As the literature reviewed above illustrates, ASD is characterised by a number of cognitive differences in aspects of theory of mind, systemizing-empathizing and the balance between behavioural inhibition and approach, that would lead to the prediction of overall more rational behaviour (in an economical sense) on an ultimatum game paradigm. One caveat to this prediction, however, is that a tendency toward systemizing may also lead to the typical pattern of fair behaviour due to an adherence to social norms. Building on earlier work by Sally and Hill (2003, 2006), the present study, therefore, aimed to shed light on the social-decision behaviour of autistic adults on a standard version of a one-shot UG, examining also those processes and individual difference factors that are thought to predict decisions on this

paradigm. Specifically, ToM abilities were tested using the Reading the Mind in the Eyes' test, which has been developed specifically for examining ToM abilities in adults (RMIE; Baron-Cohen et al., 2001). Other relevant individual difference factors were measured using relevant self-report questionnaires including the empathizing quotient (EQ; Baron-Cohen & Wheelwright, 2004) and the systemizing quotient (SQ; Baron-Cohen et al., 2003) the Behavioural Inhibition/Activation Scale (BIS/BAS; Carver & White, 1994) and the ethics position questionnaire (EPQ; Forsyth, 1980), which measures people's tendency to adhere to idealistic versus more relativistic social norms and rules.

A one-shot paradigm was employed in this first study to avoid the contribution of reciprocal learning effects to the interactions. Before exploring UG- decision behaviour in adults with and without a diagnosis of ASD, a first experiment examined decision making on the UG in a large group of undergraduate students who completed the Autism Quotient (AQ; Baron-Cohen et al., 2001) as a continuous measure of sub-clinical autism related traits. The AQ is a self-report questionnaire that assesses the domains of social skill, attention switching, attention to detail, communication and imagination, which are all areas of significant difficulty for autistic individuals who typically score 26 or above on this questionnaire. Although non-autistic individuals rarely score above this cut-off, scores nevertheless tend to be normally distributed and therefore the AQ is commonly used as a measure of the broad autism phenotype (Bailey et al., 1995).

In addition to establishing whether sub-clinical autistic traits would be related to social-decision making on the UG, this first study served to generate a sufficient number of unfair offers that could then serve for the experiment with adults with and without an autism diagnosis to ensure that this experiment could be carried out in a real and ecologically valid manner (i.e., the offers that participants would receive would be real and their decisions would have real consequences for those who had generated the offers).

2.1 Experiment 1a: One-Shot with students

Method

Participants

One hundred-seventy-five university students took part in the initial study (47 men, 128 women, $M_{\text{age (years)}} = 21.71$, $SD = 6.35$; $M_{AQ} = 21.71$, $SD = 4.76$). Participants were students attending Psychology and Law courses at City, University of London. They were recruited in classes where data collection could be organised in two short periods of around 5-10 minutes (see procedure below).

Materials & Design

The experiment was carried out on pen and paper. A pre-formatted response sheet designed by the experimenters was printed out on an A4 piece of paper (See Figure 2.1), and the following instructions were also provided:

'You will have the chance to make a small amount of money by playing a simple game. This is a game for two players. Player 1 is given £10 to split between themselves and Player 2. Player 1 can decide to split the money however he or she chooses. Player 2 has two choices. Either he or she decides to accept the offer, in which case the £10 will be split as suggested by Player 1, or he or she rejects it, in which case both players get nothing and the £10 returns to the bank.'

You will complete this task twice, once as Player 1, and once as Player 2. As it is difficult to get players together at the same time, we will ask you to play the game in two stages. In the first stage you will make an offer which will be passed on to another player in this group. In the second stage you will have the opportunity to either accept or reject an offer from another player. After both stages are complete, we will enter all accepted offers into a draw from which we will pick 10% and pay them out accordingly. Please write your e-mail address clearly in the relevant space (see next paragraph for details) on this form so that we can contact you if you are drawn for payment. If this sheet already has Player 1's offer written in, you will take the role of Player 2. All you have to do is to decide whether to accept or reject the offer given. If you accept it, you will enter the draw for the opportunity to receive the payment you accept. The other player will also enter the draw to win what s/he has proposed to keep. If you reject the offer neither you nor the other player will enter the draw and both players will be informed that the offer has been rejected. Please let us know your response to the offer by marking accordingly.

If this sheet does not have Player 1's offer written in, you will take the role of Player 1 and will need to make a split for the next player. The split should be a whole number

of pounds, between £10 for you and £0 for them and £0 for you and £10 for them. The amounts for you and the other player should of course add up to £10'

As illustrated in Figure 2.1, the A4 sheet included a decision section, where the participant could write down both decisions as proposer and as responder. The ID number from the top of the sheet was presented also here. In the sample presented here, the participant ID as proposer was 235a. For the proposer role, participants needed to write down their offer using the standard format where the first amount indicates how much the proposer keeps for themselves and the second amount indicating how much they offer to the responder. For the responder role, participants needed to circle one of two response options (accept vs. reject) to indicate their decision. The responder was identified by the experimenter by the ID assigned in the field for player 2. In the sample here '235b'.

Player 1 Email: _____ (Remove before giving to P2) PID: 235a

Player 2 Email: _____ PID: 235b



**CITY UNIVERSITY
LONDON**

Date _____

Ethical Approval Reference: **PSYETH 11/12 012**

'Instructions as above'

Player 1 Split of £10:

For you: £ _____ *For Player 2: £* _____

As soon as your offer has been given to Player 2, you will be informed of the outcome via email

Player 2 Response (delete as applicable):

Accept / Reject

Figure 2.1 Response sheet for Student UG

To assess autism-related traits, The Autism Spectrum Questionnaire (AQ; Baron-Cohen et al, 2001) was administered in printed form. Autism-related traits are found not only at high levels in people with ASD, but also on a continuum at lower sub-clinical levels in the general population. The questionnaire comprises 50 items, 10 for each one of the following domains: Social Skills, Attention Switching, Attention to Detail, Communication and Imagination. The AQ has been shown to clearly separate individuals with and without an autism diagnosis in adults (TD $\text{Mean AQ} = 16.94$; $sd\ 6.3$ (95% CI 11.6, 20.0); ASD $\text{Mean AQ} = 35.19$, $sd\ 6.5$ (95% CI 27.6, 41.1). Scores range from 0 – 50 and scores below 26 are generally thought to reflect few autism-related traits, whereas scores above 32 are typically considered a cut-off for clinically significant autistic traits (see Ruzich et al., 2015 for a recent review). In this university student population, no participant scored above the 32-point threshold and only five participants 2.9% scored in the range between the upper (32) and lower (26) thresholds

Procedure

Data was collected from three different groups of students during a few minutes at the beginning and half-way through regular lectures. Students were invited to take part in the experiment or withdraw from it after reading the UG instructions and the consent form, both projected onto the large screen in the lecture theatre. Individually signed consent forms were not requested but it was emphasized that a return of the response sheet was taken as a sign of consent. The UG was then briefly explained and participants were informed about payment implementation. Specifically, they were told that from all accepted offers 10% would be randomly selected and paid according to the UG's rules. Participants were also made aware that some offers may be chosen for a subsequent lab experiment where these offers could be shown to a number of different participants. Here, 10% of the total accepted value across those participants would be paid. Thus, it was made clear to the participating students that their decisions on the UG could have real financial consequences.

In the classroom, students played both as proposer and responder with a £10 stake to be split with a randomly selected classmate. The first part of testing (playing as proposer) was done at the beginning of the lecture, and the second part (playing as responder) was done before the break. Each participant received the paper response form which contained the description of the UG with both proposer and responder roles fully explained (see above). First participants played the role of proposer. Once everyone had written their offer, they were asked to tear the top part of the response form, which contained their identification number and contact e-mail address. The response sheets containing the offers were collected and then returned to the class during a break period (about 1 hour later) in a pseudo-random order which avoided offers going back to the original proposers. Students were now asked to play as responders and to mark the accept/reject decision and write their email address and their previously assigned ID number. Along with the response sheet, participants also received the AQ to complete. Once everyone had completed the response form and AQ, the sheets were collected, and relevant proposers and responders were re-paired (using the ID numbers) for payment. All accepted offers were entered in a draw from which 10% were randomly picked and paid out accordingly. Winners of the draw were notified by e-mail after the testing session to arrange payment.

Results

In line with expectations for general population samples, participants in the current study had an average AQ score of 14.04 ($SD = 6.35$), with males scoring somewhat higher than females though not significantly so $t(173) = 1.67, p = 0.096$ (see Figure 2.2). Noteworthy that 73% of the sample population were females.

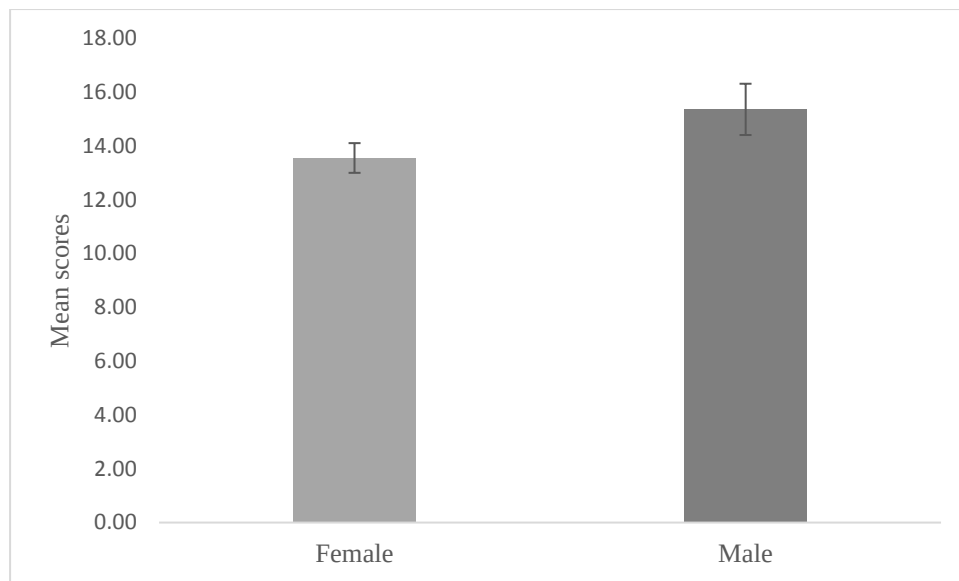


Figure 2.2 AQ Mean score by gender

The results of the One-shot UG confirmed the well-established finding for industrialized societies that over half of the participants (62%) made fair fifty-fifty split offers. The distribution of the offers made by the proposer is set out in Figure 2.3 which shows that offers of 40% of the stake were the next most common, and less than 15% of the participants made offers less than that. Interestingly round 10% of offers benefited the responder with four people offering the total £10 available to the responder and one person offering £9. These types of offers commonly known as “hyper fair offers” have been found in societies where gift giving is part of the culture (Henrich et al., 2005). This finding may reflect the heterogeneity of student backgrounds at City, or alternatively, may represent a misunderstanding of the task.

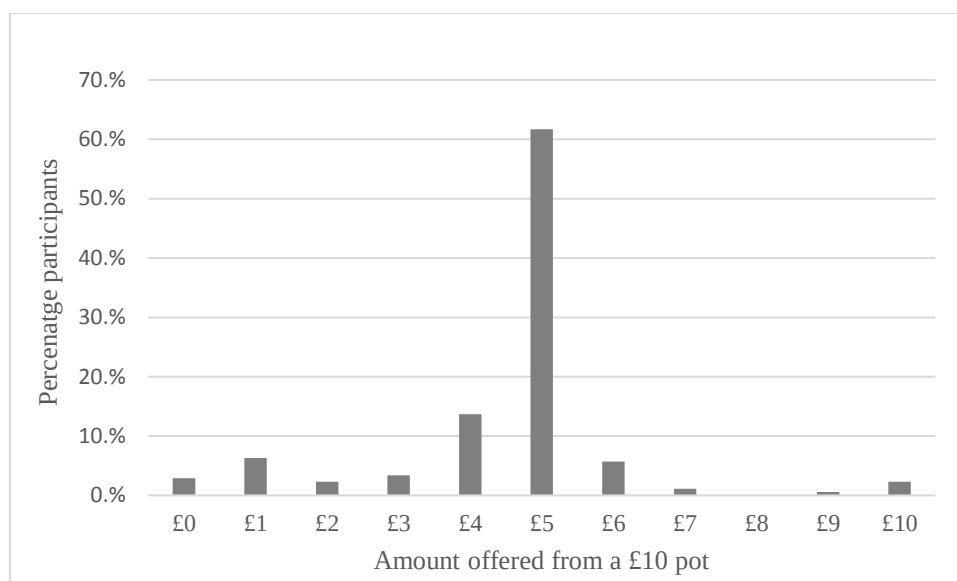


Figure 2.3 Percentage offered by the proposer from a £10 pot. Mode offer “5”

Figure 2.4 sets out the results for the responder role and shows the percentage of participants who accepted or rejected the various offers. As expected, the majority of 50:50 splits (97%), and all ‘hyper-fair’ offers that were beneficial to the responder were accepted. It is not entirely clear why around 3% of the egalitarian splits were rejected but it could be speculated that these rejections may have resulted from a misunderstanding of the study instructions. Acceptance rates declined as the value offered to the responder decreased with a considerable drop in acceptance rates for offers less than thirty percent of the total pot. Thus while £(6:4) splits were accepted by 80% of participants who received such offers, £(7:3) splits were accepted by only 33% of participants and offers less than that were nearly always rejected. It is worth remembering that this highly reliable behaviour is economically irrational (except in the case where offers of £0 were proposed) since the rejection of offers means that participants forego the opportunity to win the amount they were offered.

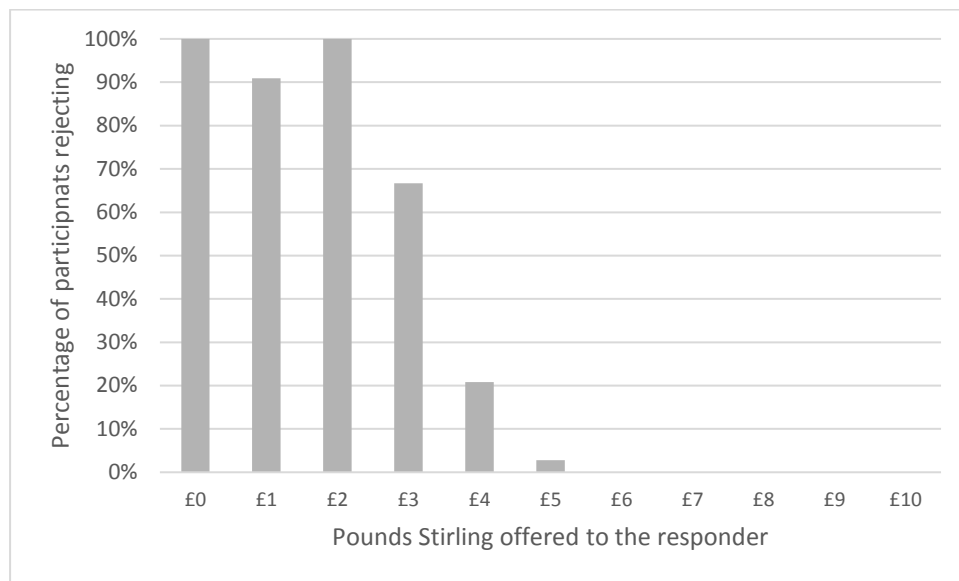


Figure 2.4 Percentage of Acceptance and Rejection as a function of the offer values in the £10 pot

Regarding the relation between decision behaviour and autism-related traits, as measured by the AQ, there was no evidence to suggest that either proposer or responder behaviour were related to individual differences in such traits. In relation to the proposer role, there was no evidence for differences in AQ scores between participants offering fair £(5:5) splits ($M = 13.62$; $SD = 6.35$) vs. unfair splits different from £5 ($M = 14.77$; $SD = 6.34$), [$t(173) = -1.14$, $p = 0.25$]; Cohen's $d = 0.18$]. Similarly, when considering the role of responders, there was no indication of differences in AQ scores between participants who accepted ($n = 55$) vs. rejected ($n = 9$) unfair offers¹¹ (Accepters: $M = 15.04$; $SD = 6.26$; Rejecters: $M = 13.11$; $SD = 7.02$; [$t(62) = 0.84$, $p = 0.40$]; Cohen's $d = 0.29$].

¹¹ Most of the (5-5) splits were accepted ($M_{AQ} = 14.00$; $SD = 6.70$) vs. rejected ($M_{AQ} = 16.33$; $SD = 8.02$)

Discussion

Study 1a, was designed to be implemented in a large group of undergraduate students (Non-clinical population) to gather the necessary unfair offers to set up the experimental study with the clinical population (ASD), and to provide some preliminary insights into the extent to which decision behaviour might be associated with autism traits as measured by the AQ (Baron-Cohen et al, 2001). Behavioural results in the UG replicated previous findings in the general population in western societies showing that as proposers individuals made 50:50 splits, and as responders these fair offers are generally accepted whereas offers of less than 30% of the pot are usually rejected. Similarly, results from the measure for autistic traits were in line with expected general population samples.

There was, however, no evidence to suggest that decision behaviour was related to individual differences in autism traits (social skill, attention switching, attention to detail, communication and imagination). Noteworthy though, that the sample in this study is not diverse enough in gender, age and subject of study. Students were chosen from the Psychology and Law degrees for practical reasons in terms of easy access to the lectures and proximity location in the campus. The current experiment could have benefitted from a more heterogeneous sample to also include students from other degrees such engineering and computer sciences, whose cognitive style has been characterized by higher degrees of systemizing, which has in turn been associated with higher AQ scores (Billington, Baron-Cohen, & Wheelwright, 2007). In a more heterogeneous sample, both the types of responses on the UG and the range of scores on the AQ would likely be characterised by greater variance, which would be more suitable for assessing associations between AQ and decision behaviour. Given the relatively low number of unfair offers that were generated, this result needs to be interpreted with some caution.

2.2 Experiment 1b: One - Shot UG with adults with and without a diagnosis of ASD

All in all, the initial study described above demonstrated the well-established pattern of proposer and responder behaviour on the Ultimatum Game, where people clearly do not only base their decisions on an objective consideration of the outcomes and income maximizing motives but on some other factors as well. Offers from proposers were predominantly fair but also included some unfair offers that will serve as materials for the next experiment described here, which will involve adults with and without a clinical diagnosis of ASD.

Method

Participants

Eighty-four adults took part in this study: Forty- three individuals with a diagnosis of ASD (34 male; 8 female) and 42 typically developed comparison individuals (31 male; 11 female). Participants were selected from an existing pool of individuals with whom the Autism Research Group at City, University of London is in regular contact. Groups were closely matched in terms of chronological age, verbal IQ, performance IQ and full- scale IQ as measured by the Wechsler Adult Intelligence Scale (WAIS-IV^{uk}; and WAIS-III^{uk}). The descriptive statistics for these variables are summarised in Table 2.1. None of the TD participants reported having a personal or familiar history of a psychological or neurodevelopmental disorder.

Table 2.1. Characteristics for autistic individuals (ASD) and Typically Develop Individuals (TD)

	ASD (34m,8f)		TD (31m,11f)				
Measure	M (SD)		M(SD)		t (84)	P	Cohen's d
Age (years)	43.69	(12.89)	43.83	(14.13)	0.04	0.96	0.01
^a VIQ	112.29	(16.85)	114.70	(15.06)	0.70	0.48	0.15
^b PIQ	106.76	(16.85)	109.41	(14.33)	0.79	0.42	0.18
^c FIQ	111.05	(17.09)	113.30	(14.65)	0.61	0.54	0.14
^d AQ	34.36	(6.74)	15.47	(6.27)	12.82	< 0.001***	2.89
^e ADOS-C	2.94	(1.65)					
^f ADOS-RSI	5.81	(2.68)					
^g ADOS-Total	8.50	(3.50)					

^a Verbal IQ (WAIS-IIIUK or WAIS IVUK); ^b Performance IQ (WAIS-IIIUK or WAIS IVUK); ^c Full Scale IQ (WAIS-IIIUK or WAIS IVUK); ^d Autism Spectrum Questionnaire (Baron-Cohen et al.,2001); ^e ADOS- Communication; ^f ADOS- Reciprocal Social Interaction; ^g ADOS Total Score- Communication + Reciprocal Social Interaction.

ASD participants were diagnosed within the UK National Health Service by experienced clinicians according to the third edition of the Diagnostic and Statistical Manual of Mental Health Disorders (DSM-III-R; American Psychiatric Association, 2013) that was in force at the time that the participants were diagnosed. In addition, administration of the Autism Diagnostic Observation Schedule (ADOS-2, Lord et al., 2012) for 34 (out of 42) participants confirmed difficulties in reciprocal social and communicative behaviours that are the hallmark clinical feature of the disorder. The Autism Spectrum Questionnaire (Baron-Cohen et al., 2001) provided further descriptive support for ASD diagnosis and confirmed that 40 (out of the 42) TD participants did not experience difficulties commensurate with ASD $t(83) = 12.98$, $p = <0.001$). The remaining two participants scored above the lower threshold (26) but since exclusion of these participants did not change the patterns of results reported below these participants were retained. Table 2.1 provides descriptive statistics for both groups.

All participants were English speakers. In line with the Declaration of Helsinki, individual written consent was obtained from all individuals upon reading the instructions of

the task. They all received a standard university fee of £8/hour for their time and transport costs were reimbursed in full. In addition, participants were also paid according to the decisions they made in the UG. All procedures received ethical approval from the Psychology Department's ethics committee.

Materials & Design

The experiment was carried out as a pen and paper study. The form used by participants to make and respond to offers was the same as that used in the Student-UG experiment, with separate forms being used for the proposer and responder stages of the task. For the role of proposer, the forms required participants to enter an ID and to specify how to split the ten pounds (£10) with another person. They were told that they would not meet with the responder. In the role of responder participants needed to indicate whether they wanted to accept or reject an offer received from a previous proposer. For this part of the task, all participants received one of the unfair £7-£3 offers from the previous student-UG reported above. Finally, all participants also completed a third part of the task which we called "Hypothetical UGs". All participants were given a form which presented all ten possible combinations of how a £10 pot could be split. Participants were required to indicate whether they would accept or reject each of these hypothetical offers by circling the relevant answers presented alongside the offers (i.e., reject / accept).

In addition to completing the UG, participants also completed measures of The RMIE (Baron-Cohen et al, 2001); The Empathising (EQ; Baron-Cohen & Wheelwright, 2004); The Systemizing Quotient (SQ; Baron-Cohen et al., 2003); The Autism Spectrum Quotient (AQ; Baron-Cohen et al, 2001); The BIS-BAS Scale (Carver & White, 1994) and the Ethics Position Questionnaire (EPQ :Forsyth, 1980), which will be described briefly here (except for the AQ, which was described already earlier).

The Reading the Mind in the Eyes Test (RMIE: Baron-Cohen et al, 2001) is a 1st-order theory of mind task that measures the ability to infer beliefs, desires and intentions to others based on expressions portrayed in the eye-region of a face. The task consists of 36 items of grey-scale photographs of the eye region of male and female faces, each associated with 4 mental state terms from which participants are asked to choose the one that best reflects what the person might be thinking or feeling (e.g. “worried”). Performance is assumed to rely on fairly unconscious, automatic and rapid matching of memories concerning similar expressions with a lexicon of mental state term, and therefore participants are instructed to choose the word that best describes the expression as soon as possible, without thinking too much about it. Half of the participants received the stimuli in ascending order (item 1 to item 36) and the other half in descending order (item 36 to item 1) to counteract possible order effects. Responses were coded as correct or incorrect, giving a maximum score of 36 points.

The empathy quotient (EQ: Baron-Cohen & Wheelwright, 2004) is a self-report measure to assess the people’s ability to identify another person’s mental and emotional states *and* to respond with an appropriated emotion to it. Given the mind reading difficulties associated with autism, the measure was developed to explore the notion that autism is also characterised by difficulties relating to and sharing the emotions of others (as indicated in the introduction, Baron-Cohen considers empathy and theory of mind to be dissociable). The EQ consists of 40 empathy-related questions (e.g., “I get upset if I see people suffering on news programmes”) and 20 filler questions. For each statement participants are asked to indicate whether they definitely agree or disagree or slightly agree or disagree and responses receive scores of either 0, 1 or 2 depending on whether empathy is not, mildly or strongly indicated. The maximum score for the empathy-related questions (filler questions are not scored) therefore ranges between 0 and 80, with higher scores indicating greater empathy.

The Systemizing Quotient (SQ; Baron-Cohen et al., 2003) is a self-report measure that was developed to detect an individual's drive to analyse a system in terms of its underlying rules and to construct systems using regularities. Paralleling the format of the EQ, the test consists of 40 systemizing items and 20 control items. An example of a systemizing item is “I prefer to read non-fiction than fiction”. Scores again vary from 0 to 80 and in addition to deriving a systemizing quotient, in combination with the EQ it is also possible to derive a Empathizing-Systemizing (E-S) difference score whereby positive values indicate a greater tendency toward empathizing than systemizing, whilst negative scores, which are commonly found in ASD, reflect a preference for systemizing over empathizing (Baron-Cohen, 2009; See Chapter one for further details).

The Behavioural Inhibition – Activation Scale (BIS-BAS; Carver & White, 1994) is a self-report instrument designed to assess people's disposition for behavioural inhibition (BIS) vs. behavioural activation (BAS). The questionnaire is made of 24 items of which four are fillers. Seven BIS items capture the extent to which participants avoid and regulate potentially aversive experiences (e.g., “*I have very few fears compared to my friends*”), whereas 13 BAS items capture distinct aspects of motivational approach tendencies including Drive (four items; e.g., *I go out of my way to get things I want*), Reward-Responsiveness (four items; e.g., “*When I'm doing well at something I love to keep at it*”) and Fun Seeking (5 items; e.g., “*I'm always willing to try something new if I think it will be fun*”). Participants are asked to rate how true the items are for them on a four-point scale ask for the likelihood of occurrence of the behaviour describe in the item. It uses a four-point Likert's scale, going from “*very true for me*” to “*very false for me*”.

The Ethics position questionnaire (EPQ; Forsyth, 1980) was administered to assess the degree of endorsement of universal moral values. The questionnaire comprises 20 attitude statements, 10 concerning idealism (e.g., *It is never ok to sacrifice the welfare of others*) and 10

concerning relativism (e.g., “Deciding whether or not to perform an act by balancing the positive consequences of the act against the negative consequences of the act is immoral”). Participants were asked to indicate their level of agreement or disagreement with each item using a nine points Liker-type scale ranging from completely disagree to completely agree.

Procedure

Participants were tested individually in the Autism Research Group’s laboratories at City, University of London. Administration of the UG and the associated measures described above took about an hour and was normally part of a longer testing session during which participants also completed unrelated cognitive assessments (e.g., experimental tasks of memory, perception of social-cognition). For the UG task, participants first played the role of responder for which the following instructions were provided:

“Attached to this sheet is the offer from another participant. Remember if you accept this offer, then you will receive the amount you have been offered and we will send to the other person what they have proposed to keep for themselves. If you reject the offer neither you nor s/he will receive payment and we will inform the other person that the offer has been rejected. To give your answer, circle accordingly to your decision”

To avoid possible observer effects, the experimenter left the testing room while the participant made their decision and only returned when the participant opened the door to signal that they had made their decision. Immediately afterwards, and keeping the interaction with the participant to a minimum, the experimenter handed over a “proposer” form which included the following reminder of the instructions for this part of the task:

“Attached to this sheet is a blank form in which you can now decide how to split £10 with another person who will take part in this experiment. Remember, you can split the £10 however you wish but please use full pound values and make sure the total adds up to £10. If the other person accepts what you offer, s/he will receive what you have offered, and we will send you the money that you have proposed to keep for yourself. However, if the other person rejects your offer

then neither you nor the other person will receive payment and we will inform you that your offer has been rejected.”

As in the first part of the task, participants made decisions in the absence of the experimenter. There was no time limit for participants to make their decisions and after participants made their offers, they were asked to respond to the 10 hypothetical offers for which it was made clear that no payments would be made. After the participant had responded to the hypothetical offers, the experimenter asked whether the participant had previous experience with similar tasks, but no one reported to have been involved in similar studies before. Participants were then asked to complete the RMIE and AQ unless data on these measures was already on file for participants (this was the case for most). Finally, the remaining self-report questionnaires were administered in a counterbalanced order (SQ, EQ, BIS-BAS, EPQ).

Analysis

Group differences were examined through independent samples *t* tests for continuous measures (e.g., self-report questionnaire scores; ToM_{RMIE}) and chi-square tests for binary data (e.g., accept/reject decisions). Decision behaviour on the UG was further examined through logistic regressions to identify possible predictors of decision behaviour across and within both groups and to account for variance due to irrelevant demographic differences between participants. For all tests an alpha of <0.05 was considered to indicate significant effects but Cohen's *d* effect sizes and Cramer's *V* for non-parametric tests are also reported to facilitate interpretation of the results.

Results

The results are presented as follows: First, the group characteristics will be set out in terms of demographic variables and the various psychological trait measures that were

obtained, including the results for the theory of mind task (ToM_{RMIE}). Then, the results for the UG are presented separately for the proposer, responder and hypothetical scenarios, and finally the logistic regression models are set out to examine, which variables might predict the decision behaviour on the UG.

Individual differences and Psychological traits

Table 2.2 presents the means and standard deviations of the scores for the RMIE theory of mind (ToM_{RMIE}) test and the psychological trait measures including the AQ, SQ, EQ, (E-S)¹², BIS/BAS and EPQ questionnaires (EPQ_R and EPQ_I). As expected, ASDs and TDs significantly differed in their scores for the (ToM_{RMIE}) with ASD participants scoring significantly lower than TD participants ($t(82) = 2.50, p = 0.014$). The ASD group also scored significantly higher than the TD group on the AQ ($t(82) = 12.82, p < 0.001$) and significantly lower on the EQ ($t(82) = 5.83, p < 0.001$), and although no differences were observed on the SQ ($t(82) = 1.31, p = 0.19$) the (E-S) difference score did. As expected, ASD participants had a significantly greater tendency for systemising rather than empathizing (i.e., negative E-S difference scores) whereas the TD group showed the opposite pattern ($t(82) = 5.68, p < 0.001$). No differences were found between the groups for the EPQ Relativism ($t(82) = 0.34, p = 0.73$), EPQ Idealism ($t(82) = 0.91, p = 0.36$) or the BAS ($t(82) = 1.66, p = 0.99$). Although the ASD group showed a significantly higher BIS score ($t(82) = 2.34, p = 0.021$), this difference was small and would not hold when controlling for multiple comparisons.

¹² Regarding the EQ and the SQ, we are mostly interested in the relation between these two measures as described by (E-S) scores. The (E-S) score results by subtracting the Systemizing scores (SQ) from the Empathizing scores (EQ). Since both measures, (EQ and SQ) comprise the same number of items, and scores reported in this thesis are normally distributed, there was no need to standardise the scores (i.e., z-transform) in order to derive the difference score.

Table 2.2 Summary of Psychological traits for the ASD and TD Group

Measure	ASD (42)		TD (42)		<i>t</i> (82)	<i>P</i>	Cohen's <i>d</i>
	M (<i>SD</i>)		M(<i>SD</i>)				
^a ToM _{RMIE}	24.19	(4.19)	26.39	(3.93)	2.50	.014	0.54
^b AQ	34.41	(6.80)	15.47	(6.27)	12.82	<.001	2.89
^c EQ	25.49	(11.82)	41.30	(12.56)	5.83	<.001	1.29
^d SQ	33.76	(13.05)	30.00	(12.63)	1.31	.19	0.29
^e (E-S)	-8.82	(17.44)	11.30	(14.04)	5.68	<.001	1.27
^f BIS	20.61	(5.03)	17.88	(5.43)	2.34	.021	0.54
^g BAS	37.07	(8.08)	34.03	(8.05)	1.66	.099	0.37
^h EPQ _R	54.41	(15.09)	53.26	(15.02)	0.34	.73	0.07
ⁱ EPQ _I	64.80	(17.26)	67.92	(12.86)	0.91	.36	0.20

^aReading the mind in the eyes test (RMIE: Baron-Cohen et al, 2001);^bAutism Spectrum Questionnaire (Baron-Cohen et al.,2001); ^c Empathising Questionnaire (EQ; Baron-Cohen & Wheelwright, 2004); ^dSystemizing Questionnaire (SQ; Simon Baron-Cohen et al., 2003); ^eDifference between Empathising and Systemizing (E-S; Baron-Cohen, 2009);^f Behavioural Inhibition (Carver & White, 1994);

^gBehavioural Approach (Carver & White, 1994);^hEthics Position Questionnaire Relativism (EPQ; Forsyth, 1980);ⁱEthics Position Questionnaire Idealism (EPQ; Forsyth, 1980).

Proposer behaviour The number of participants who proposed certain offer values is illustrated in Figure 2.5. Looking at the graph, data suggest that there were no substantial differences between ASDs and TDs regarding the proportion of fair £ (5:5) offers made. A chi-square test confirmed this impression showing that there was no difference between the groups in terms of the frequency of fair £(5:5) vs. unfair offers (offers other than £5) ($\chi^2_{(1, N = 84)} = 1.49, p = 0.20$) and the effect size associated with this difference was small ($\phi = 0.133$). Despite the statistical equivalence between groups, it should be noted that ASDs made numerically fewer fifty-fifty offers compared to TDs (ASD: 67%; TD: 79%). In addition, whereas all TD participants offered between £2 and £6, three ASD participants offered the minimum positive amount allowed (£1), and somewhat more ASD participants made offers beneficial to the responder (£6 and £7).

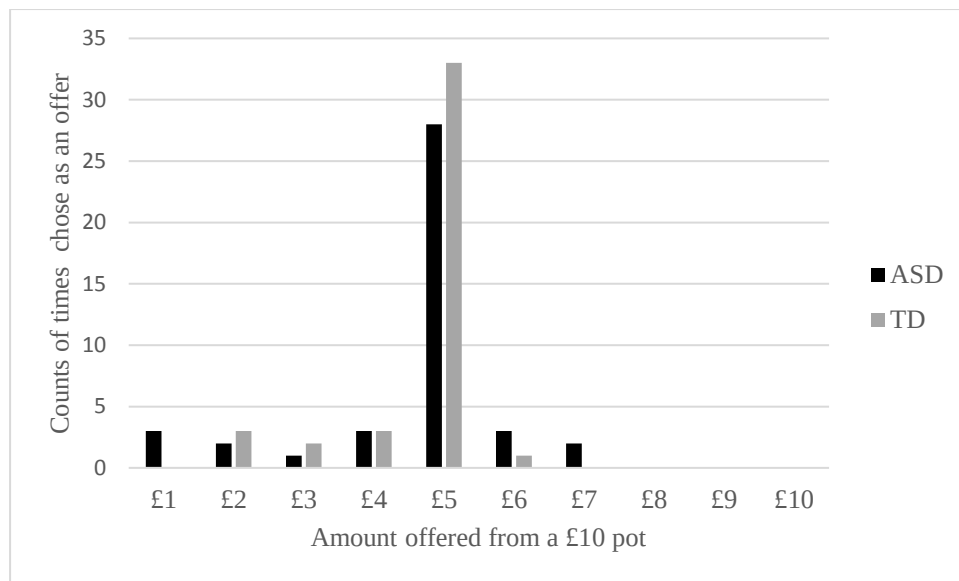


Figure 2.5 Distribution of offers by Group (TD vs ASD)

In order to explore whether the psychological measures differed as a function of Group and offers made, we created a binary variable of offers made by classifying the offers as being either Fair¹³ (£5:5) or Unfair (offers other than £5). Table 2.3 presents the means and standard deviations of the TOM_{RMIE}, AQ, EQ, (S-E), BIS, BAS, EPQ_R and EPQ_I measures as a function of Offer Type (Fair vs. Unfair) and Group (ASD vs. TD).

Several 2 (Offer type: fair vs. unfair) x 2 (Group: TD vs. AS) univariate ANOVAs were carried out for each of the psychological measures. Analyses yielded significant main effects of Group for ToM_{RMIE}, AQ, EQ and (E-S) showing the effects already described in the individual differences and Psychological traits section above. There were no differences in any of the variables between those who made fair vs. unfair offers, nor were there any interactions between these decision types and clinical group after correcting for multiple comparisons (see Table 2.3 for all ANOVA test statistics). However, for BIS there was a significant interaction between Group and Offer Type, $F(1,77) = 4.42$, $p = 0.039$, $\eta_p^2 = 0.54$. Simple main effects

¹³ Fair on this variable is equated to egalitarian division of the money

were analysed by using independent sample t-tests. Results showed that ASD participants who made fair offers, scored significantly higher in the BIS measure ($M: 21.56, SD = 4.69$) compared to TD controls ($M: 17.31, SD = 5.56$) who made fair offers $t(57) = 3.13, p = 0.03$; Cohen's $d = 0.83$. However, for unfair offers no difference in BIS between ASDs and TDs was found. In fact, although results were not significant, the trend seemed to be reversed, ASD participants who made unfair offers score lower in the BIS measure ($M: 18.79, SD = 5.35$) compared to TD controls ($M: 20.13, SD = 4.48$). However, it should be noted that, in line with most UG studies, fair offers were more frequently made than unfair offers, limiting the suitability of the data for a comparative analysis.

Table 2.3 ANOVA for psychological measures, group and proposer decision behaviour

Measure	Fair (50% - 50%)		Unfair < / > 50 %		F Group	F Dec. Prop Behaviour	F (Group x Dec.Prop Behaviour)
	TD (23) M(SD)	ASD (23) M (SD)	TD (19) M(SD)	ASD (19) M (SD)			
ToM _{RMIE} ^a	0.72 (0.11)	0.67 (0.11)	0.77 (0.09)	0.66 (0.12)	$F(1,80) = 7.93, p = 0.006; \eta = 0.90$	$F(1,80) = 0.68, p = 0.41; \eta = 0.00$	$F(1,80) = 1.34, p = 0.24; \eta = 0.01$
AQ ^b	16.10 (6.57)	33.96 (6.14)	13.13 (4.61)	35.29 (8.10)	$F(1,75) = 139.01, p < 0.001; \eta = 0.65$	$F(1,75) = 0.23, p = 0.62; \eta = 0.00$	$F(1,75) = 1.60, p = 0.62; \eta = 0.02$
EQ ^c	41.00 (12.74)	27.63 (13.16)	42.50 (12.59)	21.36 (7.46)	$F(1,77) = 30.45, p < 0.001; \eta = 0.28$	$F(1,77) = 0.58, p = 0.44; \eta = 0.00$	$F(1,77) = 1.54, p = 0.21; \eta = 0.02$
SQ ^d	29.56 (11.89)	33.04 (14.74)	31.75 (16.08)	35.14 (9.29)	$F(1,77) = 1.05, p = 0.30; \eta = 0.01$	$F(1,77) = 0.41, p = 0.52; \eta = 0.00$	$F(1,77) = 0.00, p = 0.99; \eta = 0.00$
(EQ-SQ) ^e	11.43 (14.34)	6.15(6.24)	10.75 (13.69)	-13.78(12.65)	$F(1,76) = 26.62, p < 0.001; \eta = 0.25$	$F(1,76) = 1.03, p = 0.31; \eta = 0.01$	$F(1,76) = 0.72, p = 0.39; \eta = 0.00$
BIS ^f	17.31 (5.56)	21.56 (4.69)	20.13 (4.48)	18.79 (5.35)	$F(1,77) = 1.19, p = 0.27; \eta = 0.19$	$F(1,77) = 0.00, p = 0.98; \eta = 0.50$	$F(1,77) = 4.42, p = 0.039; \eta = 0.54$
BAS ^g	33.34 (7.89)	37.59 (9.15)	36.75 (10.12)	36.07 (5.63)	$F(1,77) = 0.70, p = 0.40; \eta = 0.13$	$F(1,77) = 0.19, p = 0.65; \eta = 0.07$	$F(1,77) = 1.34, p = 0.24; \eta = 0.20$
EPQR ^h	52.94 (15.94)	53.22 (15.99)	54.50 (11.53)	56.71(13.40)	$F(1,76) = 0.10, p = 0.75; \eta = 0.00$	$F(1,76) = 0.41, p = 0.52; \eta = 0.00$	$F(1,76) = 0.06, p = 0.80; \eta = 0.01$
EPQI ⁱ	67.19 (13.77)	65.81 (15.58)	70.75 (8.56)	62.86 (20.61)	$F(1,76) = 1.36, p = 0.24; \eta = 0.01$	$F(1,76) = 0.00, p = 0.94; \eta = 0.00$	$F(1,76) = 0.67, p = 0.41; \eta = 0.00$

Note. a Reading the mind in the eyes test (RMIE: Baron-Cohen et al., 2001); b Autism Spectrum Questionnaire (Baron-Cohen et al., 2001); c Empathising Questionnaire (EQ; Baron-Cohen & Wheelwright, 2004); d Systemizing Questionnaire (SQ; Simon Baron-Cohen et al., 2003); e. Difference between Empathising and Systemizing (E-S; Baron-Cohen, 2009); f Behavioural Inhibition (Carver & White, 1994); g Behavioural Approach (Carver & White, 1994); h Ethics Position Questionnaire Relativism (EPQ; Forsyth, 1980); i Ethics Position Questionnaire Idealism (EPQ; Forsyth, 1980)

Because the previous analyses indicated no differences between autistic and non-autistic participants on UG decision behaviour, the two groups (ASD & TD) were collapsed for the final binary logistic regression analysis that sought to identify factors that might predict proposer offer Type (Fair vs. Unfair). To remind the reader, participants played first as responders and then as proposer. Therefore, along with psychological trait measures [ToM_{RMIE}, (E-S), BIS, BAS, EPQ_I, EPQ_R it was also of interest to examine whether decisions as responders (i.e., whether to accept or reject unfair offers) might predict whether participants made fair vs. unfair offers as proposers). The statistics for each predictor in a model that included all predictors simultaneously are presented in Table 2.4

Table 2.4 Summary of Logistic Regression with factors as predictors of 50-50 proposal

Predictor	<i>B</i>	Wald <i>X</i>	<i>p</i>	Exp(<i>B</i>)	95% L	95% U
(E-S)	0.04	5.66	0.02	1.05	1.01	1.08
ToM _{RMIE}	-0.61	0.07	0.80	0.54	0.01	57.31
EPQ _I	-0.01	0.37	0.54	0.99	0.95	1.03
EPQ _R	-0.04	2.74	0.10	0.97	0.93	1.01
BIS	-0.03	0.26	0.61	0.97	0.86	1.10
BAS	0.02	0.16	0.69	1.02	0.94	1.10
Responder Beh^a.	2.17	8.90	0.00	8.77	2.11	36.56
Constant	3.44	1.38	0.24	31.21		

^a Responder Behaviour

A test of the model against a constant only model was statistically significant, indicating that the combination of predictors distinguished reliably between participants who made fair vs unfair proposals (Chi square = 15.809, $p = 0.027$, $df = 7$). A Nagelkerke's R^2 of .259 indicated a medium to small relationship between predictors and responder decision behaviour. Prediction success overall was 77% (91% for 50:50 offers and 36% for offers different from 50:50). The Wald criterion demonstrated that the E-S difference score and Responder Behaviour made a significant contribution to the model. An increase in the difference between

(E-S) was associated with an increased probability of a fair (50:50) split and participants who accepted an unfair offer in the role of responders, were more likely to offer a fair (50:50) split as proposers.

Responder Behaviour Turning to the responder data, as shown in Figure 2.6, identical numbers of ASD and comparison participants accepted (55%) and rejected (45%) the unfair £ (7-3) split ($\chi^2_{(1, N = 84)} = 0.00, p = 1$; Cramer's $V = 0.00$).

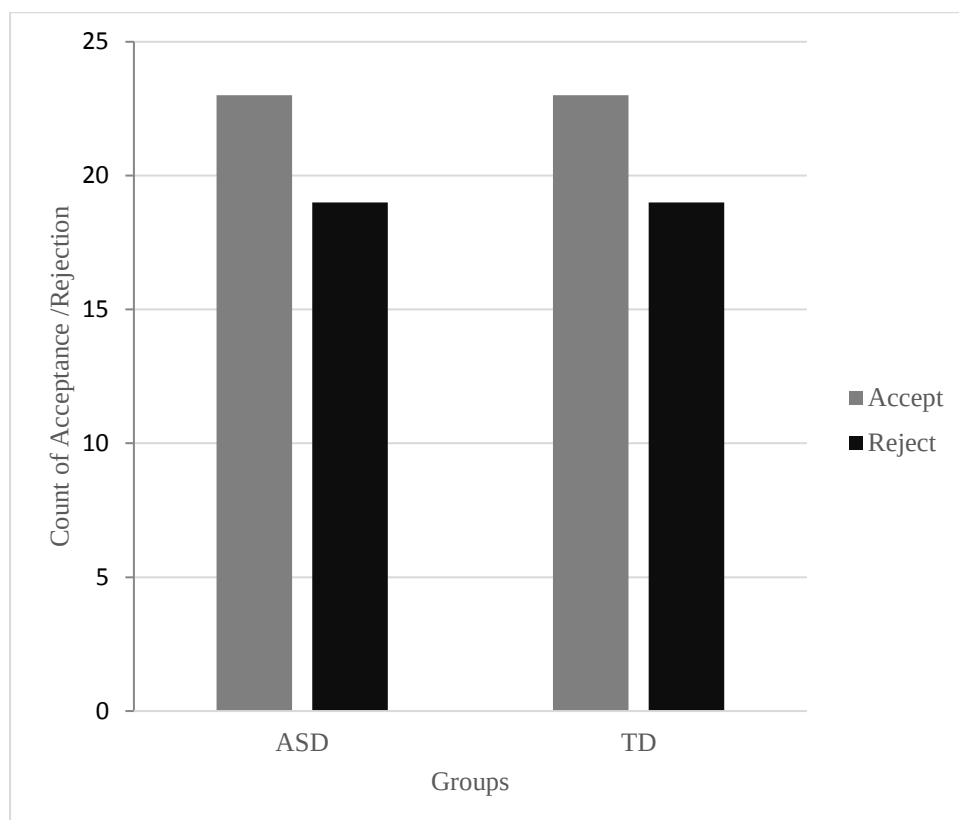


Figure 2.6 Response Behaviour towards the £7-£3 offer by Group

To examine whether any of the psychological trait measures might be related to responder decisions (Accept vs Reject), as for the proposer behaviour, several 2 (Responder behaviour: accept vs. reject) x 2 (Group: TD vs. ASD) univariate ANOVAs were carried out for each measure. Analyses again yielded the significant main effects of Group for [ToM_{RMIE}, BIS, EQ, (E-S), BIS already described but no significant effects of responder decisions were

observed (see Table 2.6 for all ANOVA test statistics). However, for the EPQ_I there was a significant interaction between Group and responder decision-behaviour, EPQ_I: $F(1,75) = 4.72$, $p = 0.03$; $\eta_p^2 = 0.05$). Follow-up comparisons indicated that TDs who accepted scored significantly higher on the EPQ_I measure ($M: 70.05$, $SD = 9.82$) compared to ASD ($M: 60.18$, $SD = 17.32$) who accept the unfair offers [$t(40) = 2.28$, $p = 0.028$; Cohen's $d = 0.70$]. However, for rejecters no difference in EPQ_I between ASDs and TDs was found [$t(40) = 0.90$, $p = 0.37$; Cohen's $d = 0.29$]. In fact, although the difference was not statistically significant, the trend seemed to be reversed such as that rejecters in the TD group scored lower in the EPQ_I ($M: 65.44$, $SD = 15.62$) compared to rejecters in the ASD group ($M: 70.16$, $SD = 15.97$). We will revisit this analysis in the context of the study reported in Chapter 5.

Table 2.5 ANOVA for psychological measures, group and responder Decision behaviour (Accept vs Reject) and group (TD vs ASD)

Measure	Accept			Reject			F Group	F Decision Resp-Behaviour	F Interaction(Group x Dec.Resp-Behaviour)
	TD (23) M(SD)	ASD (23) M(SD)	TD (19) M(SD)	ASD (19) M(SD)	TD (19) M(SD)	ASD (19) M(SD)			
ToM ^a RMIE ^a	0.75 (0.11)	0.68 (0.11)	0.70 (0.09)	0.65 (0.11)	0.70 (0.09)	0.65 (0.11)	$F(1,80) = 6.13, p = 0.015, \eta = 0.71$	$F(1,80) = 2.38, p = 0.12, \eta = 0.02$	$F(1,80) = 0.90, p = 0.76, \eta = 0.00$
AQ ^b	13.62 (6.14)	35.91 (6.74)	17.76 (5.81)	32.68 (6.63)	17.76 (5.81)	32.68 (6.63)	$F(1,75) = 166.79, p < 0.001, \eta = 0.69$	$F(1,75) = 0.10, p = 0.75, \eta = 0.00$	$F(1,75) = 6.54, p = 0.013, \eta = 0.80$
EQ ^c	42.29 (11.49)	26.41 (13.22)	40.21 (13.89)	24.42 (10.22)	40.21 (13.89)	24.42 (10.22)	$F(1,77) = 33.35, p < 0.001, \eta = 0.30$	$F(1,77) = 0.54, p = 0.46, \eta = 0.00$	$F(1,77) = 0.00, p = 0.98, \eta = 0.00$
SQ ^d	27.81 (12.53)	33.59 (13.13)	32.42 (12.64)	33.95 (13.31)	32.42 (12.64)	33.95 (13.31)	$F(1,77) = 1.61, p = 0.20, \eta = 0.21$	$F(1,77) = 0.74, p = 0.39, \eta = 0.10$	$F(1,77) = 0.54, p = 0.46, \eta = 0.00$
(EQ-SQ) ^e	14.47 (10.33)	8.19 (18.80)	7.78 (16.85)	-9.52 (16.29)	7.78 (16.85)	-9.52 (16.29)	$F(1,76) = 31.72, p < 0.001, \eta = 0.29$	$F(1,76) = 1.27, p = 0.26, \eta = 0.17$	$F(1,76) = 0.56, p = 0.45, \eta = 0.00$
BIS ^f	16.81 (5.02)	19.86 (5.13)	19.05 (5.75)	21.47 (4.92)	19.05 (5.75)	21.47 (4.92)	$F(1,77) = 5.56, p = 0.021, \eta = 0.06$	$F(1,77) = 2.75, p = 0.10, \eta = 0.03$	$F(1,77) = 0.74, p = 0.78, \eta = 0.00$
BAS ^g	34.62 (7.67)	33.55 (8.96)	33.37 (9.22)	37.68 (7.11)	33.37 (9.22)	37.68 (7.11)	$F(1,77) = 2.84, p = 0.95, \eta = 0.36$	$F(1,77) = 0.00, p = 0.97, \eta = 0.00$	$F(1,77) = 0.41, p = 0.42, \eta = 0.00$
EPQ-R ^h	53.62 (12.67)	49.18 (14.59)	52.83 (17.75)	60.47 (13.60)	52.83 (17.75)	60.47 (13.60)	$F(1,76) = 0.23, p = 0.62, \eta = 0.00$	$F(1,76) = 2.54, p = 0.11, \eta = 0.03$	$F(1,76) = 3.36, p = 0.71, \eta = 0.04$
EPQ-I ⁱ	70.05 (9.82)	60.18 (17.32)	65.44 (15.62)	70.16 (15.99)	65.44 (15.62)	70.16 (15.99)	$F(1,76) = 0.59, p = 0.44, \eta = 0.00$	$F(1,76) = 0.64, p = 0.42, \eta = 0.00$	$F(1,76) = 4.72, p = 0.03, \eta = 0.05$

Note. a Reading the mind in the eyes test (RMIE; Baron-Cohen et al. 2001); b Autism Spectrum Questionnaire (Baron-Cohen et al., 2001); c Empathising Questionnaire (EQ; Baron-Cohen & Wheelwright, 2004); d Systemizing Questionnaire (SQ; Simon Baron-Cohen et al., 2003); e. Difference between Empathising and Systemizing (E-S; Baron-Cohen, 2009); f Behavioural Inhibition (Carver & White, 1994); g Behavioural Approach (Carver & White, 1994); h Ethics Position Questionnaire Relativism (EPQ; Forsyth, 1980); i Ethics Position Questionnaire Idealism (EPQ; Forsyth, 1980)

Similar to the earlier analysis of proposer behaviour, due to the lack of group differences in responder behaviour, groups were collapsed for the final binary regression analysis to identify predictors of responder decisions, again entering all trait measures into a model simultaneously. The statistics for each predictor are presented in Table 2.6. Unlike for the proposer behaviour, a test of the full model against a constant only model was not statistically significant, (Chi square = 10,004, $p = 0.12$, $df = 6$), suggesting that none of the trait measures, either individually, or in combination are reliably associated with people's decision to accept or reject unfair offers.

Table 2.6 Summary of Logistic Regression with factor as predictors of responder decision behaviour with groups collapsed

Predictor	<i>B</i>	Wald χ^2	<i>p</i>	Exp(<i>B</i>)	95% L	95% U
(E-S)	0.02	1.92	0.17	1.02	0.99	1.05
ToM _{RMIE}	1.88	0.76	0.38	6.52	0.10	436.83
EPQ _I	-0.01	0.40	0.53	0.99	0.96	1.02
EPQ _R	-0.02	1.96	0.16	0.98	0.94	1.01
BIS	-0.10	3.41	0.07	0.90	0.81	1.01
BAS	0.04	1.31	0.25	1.04	0.97	1.12
Constant	1.32	0.29	0.59	3.73		

Hypothetical Task: The final phase of this experiment required participants to respond to all possible whole-number hypothetical offers in a £10 pot. The results of hypothetical responses to these offers are set out in Figure 2.7, and again suggest very few differences between the ASD and comparison group. A series of Chi squares tests were run to compare (ASD vs TD) responder decision-behaviour for each hypothetical offer, which confirmed no significant differences for any of them (see Table 2.7).

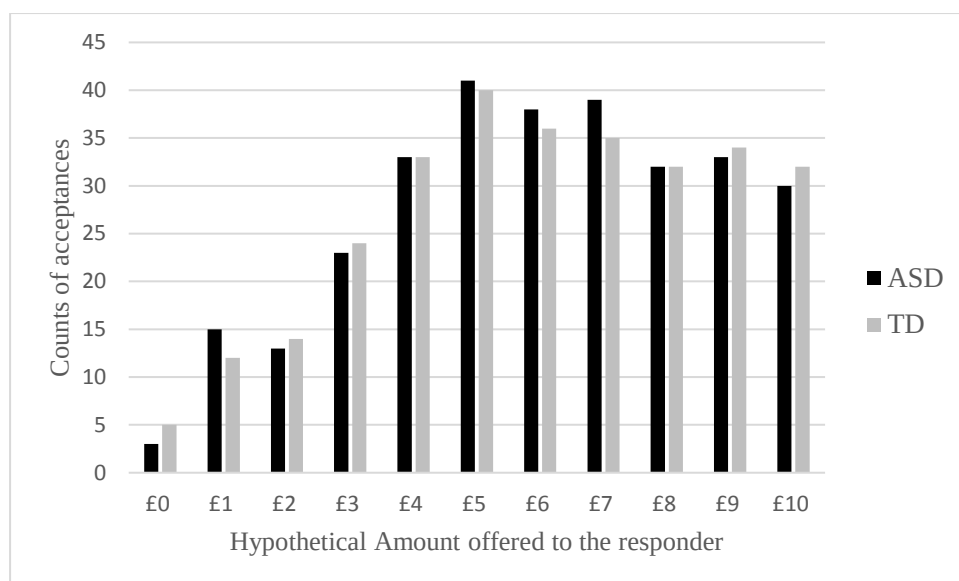


Figure 2.7 Acceptance rate for each Hypothetical Offer in a £10 pot

Table 2.7 Chi-square test comparing acceptance rate for each hypothetical game in TD and ASD

*Game	Chi square	<i>p</i>	(Phi ϕ)
Game ₀	$(X^2_{(1, N = 84)} = 0.55)$	$p = 0.47$	0.09
Game ₁	$(X^2_{(1, N = 84)} = 0.49)$	$p = 0.48$	0.07
Game ₂	$(X^2_{(1, N = 84)} = 0.05)$	$p = 0.81$	0.02
Game ₃	$(X^2_{(1, N = 84)} = 0.04)$	$p = 0.82$	0.02
Game ₄	$(X^2_{(1, N = 84)} = 0.00)$	$p = 1.00$	0.00
Game ₅	$(X^2_{(1, N = 84)} = 0.34)$	$p = 0.55$	0.06
Game ₆	$(X^2_{(1, N = 84)} = 0.45)$	$p = 0.50$	0.07
Game ₇	$(X^2_{(1, N = 84)} = 1.81)$	$p = 0.17$	0.14
Game ₈	$(X^2_{(1, N = 84)} = 0.68)$	$p = 0.79$	0.02
Game ₉	$(X^2_{(1, N = 84)} = 0.74)$	$p = 0.78$	0.03
Game ₁₀	$(X^2_{(1, N = 84)} = 0.57)$	$p = 0.45$	0.08

* Games are labelled with the amount going to responder

Finally, a McNemar test was used to compare acceptance rates across the hypothetical scenarios, combining both groups for this analysis due to the lack of differences between ASD and TD participants. The interest here was to compare the acceptance rate between equivalent splits that benefit either the proposer £(10-0) or the responder £(0-10). Confirming the existing

literature, for all pairs, the test showed that responders are less tolerant to unfair splits when the unfairness favours the proposer rather than themselves (see Table 2.8 for a summary of the analyses).

Table 2.8 Comparison of rejection rate between pairs of splits with the same distribution ratio one with the offer beneficial to the proposer (Left) and (Right)beneficial to the responder

Pair	<i>McNemar test</i>	<i>p</i>
^a (G0 - G10)	n _{G0} =76, n _{G10} =8	< .01
(G1 - G9)	n _{G1} =57, n _{G9} =17	< .01
(G2 - G8)	n _{G2} =57, n _{G8} =19	< .01
(G3 - G7)	n _{G3} =37, n _{G7} =10	< .01
(G4 - G6)	n _{G4} =18, n _{G6} =10	0.03

^a Responder gets £0, proposer get £10 (Game 0) vs (Game 10) Responder gets £10, proposer gets £0

Discussion

The present study set out to test the prediction that autistic individuals would demonstrate economically more rational decision behaviours on the UG due the combination of difficulties in theory of mind and empathizing, and the tendency for systemizing that characterises the disorder. Although these predictions find some support in the limited number of studies that have examined social-economic decision making to date, the predictions were somewhat tentative for two reasons. First, whilst a tendency for systemizing might lead to economically more rational decision behaviours on the UG under the kind of logical assumptions that have informed economic models of game-theoretical paradigms, systemizing might also lead individuals to adhere to social norms and rules dictating that a desire to achieve fair and mutually beneficial outcomes for all benefit should guide the social exchange. For this reason, people's tendencies to adhere to either idealist or relativist social norms were also examined in the current study. Second, beyond social-cognitive processes such as empathy and theory of mind, personal motivational drives are also thought to play a role in social-decision

making. Specifically, a tendency for behavioural inhibition to protect against potential aversive consequences, has been linked to fairer decision behaviours in the UG, presumably because such a drive motivates behaviours that minimize potential aversive consequences (e.g., an offer being rejected). Thus, participant's tendencies to engage behavioural inhibition versus behavioural activation processes was also assessed in the current study.

The results of the current study generally replicated that now well-established finding that, participants in an UG do not behave according to rational theories of economic behaviour. Instead of offering the lowest positive amount of the total pot possible as proposers under the assumption that rational responders should accept any amount above zero (Rubinstein, 1982b; Von Neumann & Morgenstern, 1944), proposers most frequently opt for fair offers and responders tend to reject unfair offers despite the fact that this entails giving up an opportunity for obtaining payment (Camerer, 2003). More importantly, in relation to the main predictions, the results showed no differences between ASD and TD groups in One-shot UG behaviour. As proposers the modal offer was £5 in both groups, and as responders the acceptance/rejection rate of the unfair £7:£3 split was identical in both groups with approximately half of the participants rejecting the unfair proposal. Group similarity was further corroborated by decisions on the hypothetical UG, where the results suggested that individuals in both groups were sensitive to unfair treatments towards the self. Finally, many of the individual difference variables that were expected to contribute to decision behaviour in the UG and to group differences in such behaviour, turned out not to play a substantial role, particularly in responder behaviour where none of the variables measured predicted acceptance/rejection rates of unfair offers across the whole sample of 84 participants.

Given the previous studies by Sally and Hill (2003, 2006), which indicated that ToM difficulties contribute to atypical UG decision behaviour in autistic children, particularly on the initial trial of a multi-trial paradigm, perhaps the most surprising finding of the current study

was the lack of evidence for a role of ToM in guiding decision behaviour in either ASD or TD participants. There are a number of possible reasons for this negative finding and the more general absence of group differences between ASD and TD participants. First, in relation to the role of ToM, it is important to remember that a considerable number of the studies that have implicated ToM in UG decision behaviour, have been carried out with younger children at an age where ToM may not yet have fully matured (e.g., Takagishi et al., 2010, 2014; Sally & Hill, 2003, 2004). Although brain imaging studies have implicated ToM processes also in adult social-economic decision making (Chiu et al., 2008a; McCabe et al., 2001; Rilling et al., 2004), behavioural measures may not be sensitive enough to capture such ToM processes in adults, particularly in the context of a One-shot interaction. Similarly, the tasks used to measure ToM in adults (i.e., the RMIE), may not be as sensitive to the specific aspects of ToM that may be critical for UG behaviour and that may be more appropriately captured by the tasks used with children (i.e., Sally-Ann). Specifically, the nature of the RMIE places considerable demands on face processing, and the ability to attribute emotional states to facial expressions, rather than to attribute beliefs as a way to anticipate another's behaviour as in the Sally-Ann task.

It is, however, also important to take the results at face value and consider the possibility that ToM does not play a critical role in determining rejection but acceptance in the UG. In this context, it is important to note that the literature is not entirely consistent on this point. For instance, Takagishi et al., (2014, 2010) reported that 6 years old who passed a Sally-Anne ToM task were generally more likely to make fair (50:50) proposals compared to children who failed the ToM task, and Sally & Hill (2006) observed a higher proportion of unfair offers in ASD than TD children. However, the data presented by Sally & Hill (2006) also illustrated curious differences TD children of different ages whereby 6 and 10-year olds were more likely to make fair offers than 8-year olds, who did not appear to differ much from the autistic children. If ToM abilities are a critical factor in proposer behaviour, fair offers would increase linearly with

age as was observed by Takagishi et al. Such inconsistencies suggest that ToM may not consistently be a strong driving force in decision behaviour, or it may only play a significant role in certain circumstances, such as when an individual thinks that their character might be under scrutiny (Chiu et al., 2008; Frith & Frith, 2008) or when interactions are more reciprocal, requiring an updating of beliefs about another person's intentions (Sally & Hill, 2006).

Whilst the current study did not indicate any involvement of ToM in decision behaviour, there was some evidence to suggest that a tendency to empathize rather than systemize, was associated with a greater likelihood that a person would offer a fair amount as proposer, suggesting that empathy might promote fairness. This is in line with evidence suggesting that empathy enhances behaviour that favour others and those who display more affective concern towards others are more likely to behave altruistically (Singer et al., 2006, 2005).

The other noteworthy observation in the current study was the finding that fair offers in ASD participants appeared to be more strongly motivated by the Behavioural Inhibition system (BIS) than in TD participants. Specifically, on the BIS measure autistic adults who offered fair amounts scored higher than TD adults who offered fair amounts whereas not such differences emerged for participants who offered unfair amounts. Because unfair offers were relatively scarce, this result needs to be interpreted with some caution, as it may simply be a reflection of more general group differences in BIS rather than more specific group differences in the role of BIS in decision behaviour. Nevertheless, it is worth noting that this finding is in line with previous studies which suggest that fair proposer behaviour may, in part, be driven by the behavioural inhibition system, which would motivate behaviours that avoid aversive consequences (e.g., having an offer rejected or being perceived as unfair) and confrontation (Mennin et al., 2002; Skatova & Ferguson, 2011). It is also interesting that whilst no overall group differences in BAS were observed in the current sample, the groups significantly differ

in the BIS scale. In line with previous studies, the results show increased BIS in ASD compared to TD groups (e.g., Larson et al., 2011) which are very likely to generally result in higher levels of anxiety as further indicators of greater BIS activation in ASD. Since BIS is associated with a greater tendency to make fair offers as proposers, the drive to avoid the negative consequences that might result from making unfair offers may overshadow any tendency toward more self-serving and economically more rational proposer behaviour that might result from ToM impairments and/or a greater tendency to systemize rather than empathize in ASD. In other words, different trait factors might influence decision behaviour on the UG in opposite directions, which is difficult, if not impossible, to tease out from the single observations that are gained from participants in a One-shot UG. The remaining experiments presented in chapters 2-4, will therefore make use of multiple trial UG paradigms (though participants will interact only once with any given other partner), and employ experimental manipulations and measures that aim to shed more light on the specific role different factors play in guiding decision behaviour. Before turning to these studies, it is useful to highlight an important implication of the current findings. Specifically, although a One-shot task may be poorly powered to detect the kind of influences on social-decision behaviour that are of interest in the current thesis – influences of Theory of Mind, empathizing/systemizing, EPQ, BIS/BAS - an advantage of such tasks is that they have very high face validity. In this respect the absence of any group differences may have some positive implications for the day-to-day lives of autistic individuals. Specifically, the typical patterns of behaviour observed in the current study, would suggest that, at least in the context of single socio-economic transactions, such as those involved in bargaining about purchase prices of goods, autistic individuals appear no more susceptible to exploitation than TD participants, nor would they be at greater risk of being perceived as unfair.

3 EXPERIMENT TWO: PHYSIOLOGICAL RESPONSES AND DECISION BEHAVIOUR

The results of experiment 1 reported in the previous chapter, in which autistic (ASD) and typically developing (TD) participants completed an ecologically valid One-shot ultimatum game, showed similarly fair offers and identical proportions of rejections of an unfair (£7 - £3) offer in both groups. Moreover, of all the measures that were examined as possible predictors of decision behaviour: ToM, Empathizing – Systemizing (E-S), Behavioural Approach and Inhibition (BIS/BAS) and Ethical positions (EPQ), only the E-S difference score and BIS drive predicted the probability of participants making fair offers, with BIS playing a role in this respect, only for ASD participants. No factor predicted acceptance or rejection rates of unfair offers as responders. The broad equivalence between groups in experiment 1 was surprising given the wider literature, although it is likely that the nature of a One-shot UG may not be sensitive to the differences that might be expected.

As will be explained in this chapter, following pioneering work by (Civai et al., 2010; Pillutla & Murnighan, 1996; Sanfey et al., 2003) a large body of research has emerged suggesting that responder behaviour in the UG, is the result of emotion processing activated when individuals are presented with offers that favour the proposer (i.e., unfair offers). Therefore, this next experiment was designed to examine the mechanisms involved in the decision-making process during the UG in more detail, focussing in particular on the role of ToM and emotion-related processes. Further scrutiny of these mechanisms is important given evidence that an absence of group differences in certain overt behaviours between ASD and comparison participants can often be observed in the context of differences in the mechanisms

involved in mediating the behaviour (Begeer et al., 2010; De Martino et al., 2008; South et al., 2011)

As will be described in this section, there is increasing evidence suggesting that the boundaries between emotion and cognition in decision making are less well-defined than previously thought (Camerer, 2003b; Lieberman, 2007a, 2007b; Loewenstein, 2000; Sanfey et al., 2007; 2003). Emotional processes, such as the physiological arousal induced by the unfairness of an offer, have been shown to play a significant role in determining decision behaviour on the UG (Van't Wout, et al., 2006) and, social-cognitive processes such as theory of mind (Blount, 1995; Rilling et al., 2004) are also thought to play a role. In light of this evidence, the difficulties that individuals with ASD demonstrate in various aspects of social cognition and in processing emotional information (Bölte, Feineis-Matthews, & Poustka, 2008; Chevallier et al., 2012; McDonald, 2013; Silani et al., 2008) would lead to the prediction that decisions on the UG should be less affected in ASD by the emotions generated by unfair offers and by the intentionality of proposers. The experiment set out in this chapter will test these predictions by recording physiological arousal levels to fair and unfair offers in a paradigm developed by Van't Wout, et al., (2006) in which offers are either proposed by intentional agents (other humans) or are randomly generated by a non-intentional machine (a computer). Before setting out the details of this experiment, some of the relevant literature will first be summarised regarding the role of emotional and social-cognitive processes in human interaction.

Awareness of emotional cues and sharing of emotional information have decisive influences on people's social behaviour. Emotions affect cognitive processes and behaviour across multiple functional domains, including the regulation of attention and perception, modulation of learning and the processes involved in decision behaviour (e.g. Damasio, 1994). Together these wide influences serve to ensure the survival and wellbeing of the organism by

regulating behaviour to avoid danger whilst seeking out reward and appetitive stimuli (Barrett, 2013; Barrett, Ochsner, & Gross, 2007). In decision making, emotion has been shown to play an important role in moral judgment (Greene et al. 2004) and more broadly, the relation between emotion and decision making has gained attention in economy (Loomes & Sugden, 1982) and in psychology, with studies showing that emotions function as the guiding compass when choosing between options that vary in terms of their value to the organism (Damasio, 1994; Loewenstein, 1996; Zajonc, 1998).

The way in which people integrate emotion-related information with ongoing cognitive processes plays an important role in determining socio economic behaviour. Standard models of economics, assume that the utility of an action depends only on the positive difference between the outcome *versus* expected outcome, and therefore the focus has been on post-decision emotions, such as regret and disappointment (Lerner & Keltner, 2000). However, other models, which have shown that people are not always simply interested in outcomes, suggest that decision behaviour is also influenced by the emotion experienced during the decision-making process. Here, research has looked at a wider range of emotions (Forgas, 1995), and considered the effects of both incidental emotions, that are unrelated to the task, and integral emotions that are directly elicited by the task (for a review see Rick & Loewenstein, 2008). Incidental emotions are generated by external and contextual factors, such as the weather, ambient noise or events that are unrelated to the task but that nevertheless affect decision making (Lieberman et al., 2011) and not always in a conscious way (Bonini et al., 2011).

Bonini et al., (2011) tested the effect of incidental emotions in the UG. Participants were asked whether to accept or reject an unfair offer of \$2 out of \$10. Participants were tested in one of two contexts; a room with an unpleasant smell or a room with no smell. There were

significantly more acceptances of the unfair offer in the smelly room compared to the neutral room, leading the authors to suggest that participants in the odour condition misattributed the disgust associated with the unfairness (integral emotions) to the disgusting smell in the room (incidental emotions), leading to a reduced tendency to direct a negative behaviour to the unfair offer. This interpretation implies that rejections of unfair offers are, at least in part, motivated by the aversive feelings that unfair offers would typically elicit – i.e., the integral emotions in the task.

In the context of social decision-making tasks such as the UG, integral emotions are thought to derive not only from the fairness or equity of a proposed offer but also from the perceived causes of any unfairness or inequity. For instance, an unfair offer made intentionally by a rich person is more likely to cause anger and disgust than an unfair offer from a poor person or from a rich person made by accident. Manipulating the fairness and causes of unfair offers, have thus proven an effective way to explore the relation between integral emotion and decision making in the UG, as exemplified by Blount (1995). Participants in this experiment were assigned to one of three conditions which differed in the type of proposer: In the interested party condition, the proposer was another human who had a stake in the game; in the third-party condition, a human partner was involved who would not get a payoff; and in the random condition the proposer was not human but a computer, which served to remove intentionality and self-interest. Rejection rate comparisons between the three conditions showed higher rejection in the interested party condition than when offers were randomly made by a computer device; whereas rejection rates in the third-party condition fell in between. The results were interpreted as evidence to show that the expectation people have of the offers is contingent to proposer type, this confirming that people have normative expectation about other people's behaviours in the UG.

Similar results were found by Sanfey et al., (2003) who, presented responders with 20 offers (fair and unfair), 10 of which were generated by human proposers and 10 were generated by computers. fMRI scans taken during decision-making, examined activation in the insula, a brain region involved in the processing of disgust (Wicker et al., 2003) and pain experiences (Pillutla & Murnighan, 1996). The data showed significantly greater activity in this region for unfair vs. fair offers from humans, and greater activation for unfair offers from human vs. computer proposers. What is more, insula activity reliably predicted rejection of unfair offers coming from human proposers, which agrees with the findings of Pillutla and Murnighan (1996), who found that responders in the UG who self-reported anger due to the unfairness of the offer, were more likely to reject unfair offers and accept losses of some money to punish unfair proposers. A number of other studies consistently show that integral emotions predict decision behaviour (Rick & Loewenstein, 2008; for an extensive view see De Houwer & Hermans, 2013), and it is therefore generally accepted that emotional processes play a significant role in regulating decision behaviour (Damasio, 1995).

But how do our emotions influence our decision making? According to the Somatic Marker Hypothesis (Bechara et al., 2000), the emotional consequences of our experiences are recorded alongside sensory and motor representations in memory from where they can be reactivated when we encounter similar situations again in the future. The reactivated emotional information includes physiological markers such as changes in endocrine release, muscle tone, heart rate, and general arousal, which have intrinsic aversive or appetitive values due to the sensory information they are associated with in memory. As a result, *somatic markers* can prompt either avoidance or approach behaviours relative to the stimuli that elicit them and this is often independent of conscious awareness (Bechara & Damasio, 2005).

Among the first demonstrations of the influence of somatic markers on decision behaviour was in the context of the Iowa Gambling Task (IGT), which requires participants to

choose cards from one of four decks with the aim to win as much money (or as many points) as possible (Bechara et al., 1997; Bechara & Damasio, 2005). Each choice leads, probabilistically, to certain amounts of winnings and losses and unbeknownst to the participants the decks are arranged so that 2 decks are overall advantageous (i.e. they yield on average greater wins than losses), whilst the other 2 decks are disadvantageous. Unsurprisingly, participants learn to choose more frequently from the advantageous decks over the course of 100 decisions. Bechara and colleagues, however, were also able to show that even before participants shifted their decisions toward the advantageous decks, increases in arousal in the form of elevated Skin Conductance Responses (GSRs) could be observed, which were absent in patients with ventro-medial prefrontal cortex (vmPFC) lesions, who failed to show a shift in decision making toward the advantageous decks (Bechara et al., 1997). Moreover, Crone et al., (2004) showed that adults selected advantageous options faster than disadvantageous options and this was also preceded by skin conductance increases and greater heart rate deceleration. Together, these and other studies provide strong evidence to suggest that somatic markers play a significant role in decision behaviour by signalling the value of possible decision outcomes.

Returning to the UG, when responders are confronted with unpleasant unfair offers, somatic markers associated with the negative emotions that are triggered, may lead to a defensive reaction that lead people to reject without considering, for instance, the financial benefit of accepting the offer¹⁴. Interestingly, in the studies outlined earlier by Sanfey et al., (2003), the fMRI data indicated that only unfair offers from a human proposer elicited activation in brain areas typically involved in the expression and experience of disgust and anger whereas unfair offers randomly generated by a computer did not. Van't Wout et al. (2006) subsequently examined whether this pattern of results would extend to somatic markers

¹⁴ However as explained earlier in Chapter 1, decision behaviour in the UG can be explained by other motives than financial gains.

(Bechara & Damasio, 2005) by examining the relation between SCRs and the subsequent decision to accept or reject unfair offers from either a human or computer proposer. Thirty students (12 males; mean age 21.25 years) were invited to play 20 UGs with an endowment of 5 euro each time. On half of the trials, offers were made by human proposers (a different one each time) whereas on the other half of the trials, offers were generated by a computer. In each condition (human – computer), half of the offers were fair (2.50 euro to each player), whereas the other half were unfair with the human/computer proposer offering only either 0.50, 1.00 or 1.50 out of 5 Euros to the participant. As predicted, higher GSR was associated with higher rejection rate to unfair offers coming from human compared to computer-generated offers, thus supporting economic models that acknowledge a role of emotions on decision making (Andrade & Ariely, 2009; Damásio et al., 2013; De Martino, Kumaran, Seymour, & Dolan, 2006; George Loewenstein & Lerner, 2003).

As outlined in Chapter 1, among the defining social-cognitive characteristics of ASD are difficulties understanding, empathizing with and reciprocating emotional expressions of others. Specifically, there is now a wide consensus that people with autism have difficulties recognising and relating to the emotions of other people. Studies show that autistic individuals attend less to the emotions of others (Ben Shalom et al., 2006; Charman et al., 1997) have difficulties recognising and labelling other people's emotions correctly (Gross, 2004; Hobson, 1986) and there is some evidence suggesting that they also empathise with others' emotions to a lesser extent although the evidence here is more contentious (Adolphs, 2002; Baron-Cohen et al., 2000). Although these difficulties were once considered to be a fairly specific feature of the social impairments that characterise ASD, more recent studies have shown that the emotional salience of information and situations more generally does not modulate cognitive processes and the behaviour of autistic individuals in typical ways, although the evidence here is still fairly scarce (see Gaigg, 2012 for a review).

At the physiological level, autistic individuals generally seem to respond with similar physiological responses to emotional stimuli, except social ones like faces (Ashwin et al., 2006). Physiological responses such as GSR and changes in heart rate, for instance have been reported to function in a similar fashion in ASD as in TD participants (Corden, Chilvers, & Skuse, 2008; Gaigg & Bowler, 2007, 2008), even if participants do not always seem to be aware of these physiological signals in terms of subjective feelings (i.e., Alexithymia; see Gaigg et al., 2018; Hill, Berthoz, & Frith, 2004). Albeit not from social decision-making tasks but from risk-based decision tasks, e.g. the IGT, evidence by Johnson et al., (2006) and South et al., (2008) suggests that physiological responses do not modulate decision behaviour typically in ASD. For instance, Johnson et al., (2006) instructed a group of 29 young adults matched in IQ and age (14 clinically diagnosed ASDs) to win as much money as possible in a IGT over 150 trials. During the task, GSR was recorded as a measure of autonomic responsiveness. Participants started the game with \$5 credit and were informed that they would receive their gains at the end of the session. Participants were shown images of four decks of cards labelled A, B, C, and D, which were displayed horizontal and “face down”. Participants were instructed to select a card by touching the screen. There was no time limit for card selection and participants were not informed about the total number of trials and the decks contingencies (A & B decks resulted in small reward and small punish, compared to C&D which resulted in large rewards and punishment). Participants were told that they could switch between decks whenever they liked. Once a card was selected, the participant was able to see the amounts won and lost and this feedback remained on the screen for 3s, in addition participants were always presented with the total earnings on the feedback screen.

To enable GSR data collection a 6s inter-trial interval was implemented. Both groups, demonstrated similar proportions of overall advantageous selections. However, analysis of selection sequences within each group revealed highly distinct selection patterns in the ASD

group. ASD participants shifted more frequently among the cards and this was interpreted as limited responsiveness to the motivational significance of previous experienced gains (losses) during the task. Moreover, the groups (ASD vs TD) differed significantly on post-selection SCRs for advantageous decks, with the ASD group consistently producing lower SCRs. Whilst this finding was not associated with group differences in the proportion of advantageous vs. disadvantageous deck choices, it does suggest that emotion-related processes may play a different role in decision-making paradigms in ASD vs. TD participants.

Given the literature set out above, the second experiment presented in this chapter builds on the paradigm developed by van 't Wout et al., (2006) to examine whether 1) the typical responder behaviour in a one-shot UG by autistic adults observed in Experiment 1 would replicate in a multi-trial UG paradigm, 2) whether rejection rates would be typically modulated by the intentionality of unfair offers (i.e., human vs. computer) in ASD and 3) whether the body's bio-regulatory signals such as galvanic skin response (GSR) play a similar role in regulating decision behaviour in the UG in ASD and TD participants.

Based on the results from experiment 1, we expected no differences in the overall acceptance/rejection rates between TD and ASD participants. Regarding the effects of the proposer manipulation (human vs. computer) on both physiological responses and decision behaviour, the tentative prediction was that this would have less of an effect on the ASD than the TD group on the assumption that ToM difficulties in ASD would make the intentionality of offers less salient to them. Specifically, whilst TD participants are expected to reject fewer unfair offers from computer vs. human proposers, and also demonstrate greater physiological arousal to human vs. computer unfair offers, these proposer effects would be attenuated in ASD. This prediction is tentative, because the results of Experiment 1 indicated that individual differences in ToM did not influence rejection rates in a One-shot game, and in the multi-trial studies of UG behaviour with children by Takagishi et al., (2014), differences in ToM between

children had significant influences on proposer but not on responder behaviour when the decision is to reject (Schug et al., 2016). Moreover, in one of the experiments presented by Sally & Hill (2006), a manipulation human vs. computer interactive partner in a Prisoner's Dilemma game (see Chapter 1 for details of this paradigm), has similar effects on both TD and ASD children. Despite these findings, however, the wider literature suggests that direct manipulations such as those implemented in the current study and by Sally & Hill (2006) do modulate decision behaviour in game theoretical paradigms, and if ToM plays a role, as is assumed, the difficulties in ToM associated with ASD should lead to differences in how such manipulations affect behaviour (this was also the prediction by Sally & Hill, 2006) and/or emotional responses.

3.1 Method

Participants

In total, 72 adults (36 ASD) were recruited from an existing database to achieve groups that were closely matched on chronological age and intellectual functioning (Wechsler Adult Intelligence Scale (WAIS-III^{UK}; The Psychological Corporation, 2000). ASD participants had all been diagnosed according to Diagnostic and Statistical Manual of Mental Disorders (4th ed.; DSM-IV) criteria by experienced clinicians within the UK National Health Service, and administration of the Autism Diagnostic Observation Schedule (Lord et al., 2000) and Autism Spectrum Questionnaire (AQ; Baron-Cohen et al., 2001) provided further support for the diagnosis. Although the ADOS could not be administered to two participants, and the AQ to one ASD participant, all ASD participants completed at least one of these assessments and all scored above relevant cut-off scores on one, or both of the instruments.

Specifically, 33 out of 35 ASD participants scored 26 or higher on the AQ, which is the cut-off recommended by Woodbury-Smith et al., (2005) for clinically referred individuals, and 25 out of 34 participants scored at or above the total algorithm cut-off score of 7 on the ADOS

(module 4) with the remaining participants scoring either 5 ($n = 6$) or 6 ($n = 3$). All TD participants also completed the AQ and none scored at or above the higher cut-off scores of 32 recommended by Woodbury-Smith et al., (2005) for screening of non-referred samples (3 TD participants scored 26, 27 and 28 respectively). Table 3.1 provides details of the group characteristics.

This study was approved by the Department of Psychology Ethics Committee of City, University of London and the procedures outlined below adhere to the ethical guidelines set out by the British Psychological Society. Participants Characteristics for ASD and TD Individuals.

Table 3.1 Characteristics for ASD and TD Individuals

	ASD (30m,6f)		TD (25m,11f)				
Measure	M (<i>SD</i>)		M(<i>SD</i>)		<i>t</i> (70)	<i>P</i>	Cohen's <i>d</i>
Age (years)	46.92	(12.35)	49.64	(14.20)	0.86	0.38	0.20
^a VIQ	114.94	(15.08)	112.78	(12.45)	0.66	0.50	0.15
^b PIQ	110.92	(16.45)	106.25	(13.57)	1.31	0.19	0.30
^c FIQ	114.17	(16.13)	110.53	(12.17)	1.08	0.28	0.25
^d AQ	36.97	(6.70)	15.19	(7.00)	13.39	< 0.001	3.18
^e ADOS-C	2.71	(1.55) *[0-6]					
^f ADOS-RSI	5.68	(2.50) *[1-13]					
^g ADOS-Total	8.38	(3.28) *[5-17]					

^a Verbal IQ (WAIS-IIIUK or WAIS IVUK); ^b Performance IQ (WAIS-IIIUK or WAIS IVUK); ^c Full Scale IQ (WAIS-IIIUK or WAIS IVUK); ^d Autism Spectrum Questionnaire (Baron-Cohen et al.,2001); ^e ADOS- Communication; *[In brackets range of scores for ADOS] ^f ADOS- Reciprocal Social Interaction; ^g ADOS Total Score- Communication + Reciprocal Social Interaction.

Materials & Design

Twenty-four offers were generated for this experiment including twelve (£5:£5) fair and twelve unfair offers - four each of £9: £1, £8:£2 and £7:£3. Half of each type of offer was presented as a randomly generated computer offer whilst the other half was presented as human generated offers. For the computer condition, a short animation lasting 17 seconds was created, which first showed an image of a computer monitor that displayed the message ‘loading...’ for

10 seconds¹⁵, before showing ‘*Computer offers £X...*’ for 2 seconds and finally revealing the full message ‘*Computer offers £X and keeps £Y*’, which remained on the screen for another 5 seconds. Immediately after the full description of the offer appeared participants were shown the message “*Do you want to accept (A) or reject (R) the computer’s offer*”, which remained on the screen until participants gave a corresponding keyboard response (a vs. r). For the human condition, videos were previously recorded, which showed proposers (one for each offer), typing offers into a computer. The framing of the videos was such that proposers were filmed over their shoulder from behind so that their faces could only be seen very partially out of focus, whilst the key board they were using, and the computer monitor they were looking at were clearly visible. The proposers were confederates who were instructed to type in offers that had previously been generated by other participants (i.e., those in Experiment 1 of the current thesis) and that would serve as the materials for the current study. The instructions to the confederates also specified that they should type in the offers at a certain pace so that the timing of the events on the video would correspond to the timing of the events set out above for the computer-generated offers (i.e., 10 second period of generating the offer followed by revealing first the offer value for 2 seconds and then the offer and retention values for another 5 seconds). As the confederates typed in their offers, the values they typed appeared clearly on the screen in front of them. The videos that were generated in this manner were displayed to the participants of the current study with a fictitious first name shown below to individuate proposers. Following each video participants were again prompted for their response with the message “*Do you want to accept (A) or reject (R) [e.g. Elizabeth’s] offer*”.

For the recording of Skin conductance responses (SCRs), an ADInstruments PowerLab System (ML845) including a GSR (ML 116) and bioelectrical signal amplifier

¹⁵ Dots were added to this message one at a time at 250ms intervals until 4 dots were shown, at which point all dots disappeared and reappeared one at a time, thus giving the impression that some computer processing took place to generate the offer.

(ML408 with MLA2540 and MLA2505 5-lead shielded Bio Amp cables) were used, which was coupled with the stimulus presentation computer to allow event markers to be recorded on the physiological trace, to indicate the onset of stimuli. Physiological signals were recorded at a rate of 1kHz in LabChart 7 (ADInstruments, 1994-2011), which was used also for subsequent offline processing of the data.

Procedure

All testing was done in a quiet, dimly lit room at City, University of London, where participants were given the following instructions about the task:

“The task we would like you to complete today is a decision-making task in which you will be presented with offers of a share of £10. Some of these offers will be randomly generated by a computer. Other offers are those of other people who have taken part in a previous stage of this experiment and who agreed for us to film them – their faces are blurred to protect their anonymity. Your task will be simply to decide whether you would like to accept or reject each offer. For every offer you accept, you will receive 10% of the value offered to you. If, the offer was made by another person, they too will receive 10% of the value they proposed to keep for themselves. For offers you reject there will be no payments to anyone.

Example: Out of £10 a person offers you £5 and would like to keep £5 for themselves. If you accept this proposal both you and the other person will receive £0.50 (fifty pence). If you reject this proposal neither you nor the other person would receive any payment.

In summary, you will be asked to respond to several offers and the amount of your earnings will be displayed at the end of the task. To indicate your decision, simply press the letter “a” to accept an offer or “r” to reject it.

Throughout the task, we would like to monitor your heart rate and how much your fingertips sweat. This is because we are interested to find out how the decisions people make in this task are related to their physiological responses to the offers they receive. Therefore, at the beginning of the experiment, electrodes would be attached to the middle and index finger of your non-dominant hand and we would ask you to wear some electrodes on your chest to monitor your heart-rate “¹⁶

Once participants confirmed that they understood the task, and after signing the consent form, equipment for recording the physiological measures was set up. The GSR electrodes,

¹⁶ Please note that whilst Heart Rate was monitored in this experiment, the results of this data are not presented in this thesis due to difficulties that arose during the analysis that could not be overcome within the time-frame available to submission.

were attached to the medial phalanges of the index and ring fingers of the participants' non-dominant hand using fitted Velcro tapes and the participant was asked to position two (positive and negative) self-adhesive snap connect ECG electrodes on the left and right sides of their chests with a reference electrode being attached to the elbow. Participants were encouraged to sit comfortably and to avoid unnecessary movements during the testing session to avoid movement artefacts. Before starting the UG task 2 minutes of baseline were recorded to ensure a correct attachment and conductance of the electrodes and to allow physiological signals to settle on a baseline.

Following a brief reminder of the instructions for the UG task, computer and human offers were presented in random order using the stimulus presentation program E-Prime (version E-Studio, v.2.0.8.90; www.pstnet.com). Each trial began with a '*please wait for the next offer*' screen that lasted 10 seconds to allow any physiological responses to previous trials to recover. After this wait slide, offers were presented as described in the materials section above. There was no time limit for participants to make their responses. Once responses were entered the next trial began, again with the 10 second "*Please wait for the next offer*" screen. At the end of the 24th trial the participant saw a screen showing the amount of money earned for all accepted offers (i.e., 10% of the accepted values) followed by a screen thanking them for their participation. Throughout the task, the experimenter stayed in the room behind a dividing screen next to the participant, to monitor the psychophysiological recordings.¹⁷

¹⁷ There is evidence by (Bolton & Zwick, 1995) suggesting that the presence of the experimenter has little to nothing influence on decision behaviour in this type of Lab based experiments however we do not know whether the presence of an experimenter might have effects on people with ASD and to the best of our knowledge there are not studies specifically addressing this topic.

3.2 Analysis

Statistical analysis was performed in IBM SPSS v22. The level of significance was set at $\alpha=0.05$. All data were tested for normality of distribution using Kolmogorov-Smirnov test. The Levene's statistic was used to test data for homogeneity of variances across groups. Data, which did not meet the criteria for homogeneity of variances and normality of distribution (GSR data) were log transformed.

For the analysis of the GSR data, the peak response during the 7-second window during which the offer was presented to participants (see materials section) was subtracted from the GSR level during the last 2 seconds of the '*wait for next offer*' screen, to provide an index of the participants' trial-by-trial arousal response to the offers, prior to giving their decisions. Following the procedures of van 't Wout et al., (2006) (see also Venables & Christie, 1980), increases in GSR levels from baseline of more than 0.02 μS were considered to indicate a reliable response and trials on which the amplitude was greater than 3 standard deviations above the mean of all other trials were considered artefacts and excluded from further analysis (9 trials were excluded on this basis in total). The mean amplitude of all remaining responses was calculated across the experimental factors of interest (e.g., GSRs related to fair vs. unfair offers or rejected vs. accepted offers) and a log transformation ($\log(\text{GSR}+1)$) of the raw data was performed to normalize the distribution of the data (Venables & Christie, 1980).

3.3 Results

Behavioural data

Figure 3.1 sets out the rejection rates of the different offers as a function of proposer (human vs. computer) and participant group (ASD vs. TD). To examine the extent to which rejection rates are moderated by the offer values, the type of proposer and the participant group, a 2 (Group: ASD vs TD) x 2 (Proposer: Human vs Computer) x 4 (Offer: £1, £2, £3, £5) repeated measures analysis of variance was performed.

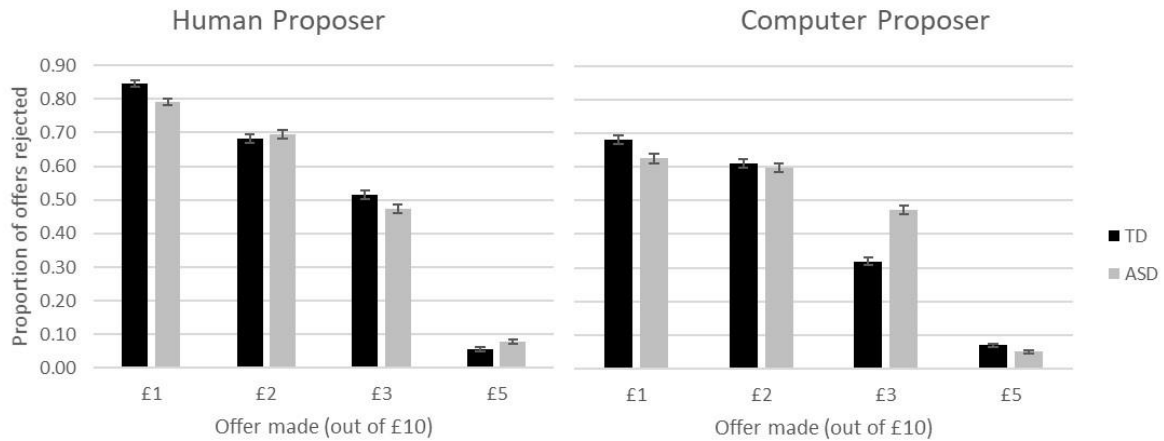


Figure 3.1 Proportion of rejected offers as a function of, proposer type (human vs. computer) and participant group. Error bars indicate ± 1 SE.

The analysis yielded significant main effects of offer, $F(3,210) = 101.63$, $p < .001$, $\eta^2 = 0.59$, Proposer $F(1,70) = 9.93$, $p = .002$, $\eta^2 = 0.124$ but not group $F(1,70) = 0.00$, $p = .994$, $\eta^2 = 0.000$. The offer main effect confirms the well-established UG phenomenon whereby rejection rates increase as a function of the unfairness of offers. In the current experiment, offers of less than £5 ($M = 0.61$, $SD = 0.35$) were rejected significantly more often than fair offers ($M = 0.06$, $SD = 0.19$; $t(71) = -12.947$, $p < 0.001$; Cohen's $d = 1.90$). The main effect of proposer confirms the findings of van 't Wout et al., (2006) that unfair computer-generated offers ($M = 0.55$, $SD = 0.41$) were rejected significantly less often than unfair human generated offers ($M = 0.67$, $SD = 0.36$; $t(71) = 3.124$, $p = .003$; Cohen's $d = 0.29$).

In addition to the main effects, the behavioural data were also characterised by a proposer $\times$ offer interaction $F(3,210) = 3.62$, $p = 0.014$, $\eta^2 = 0.05$, which was further characterised by a marginally significant 3-way interaction between group, proposer and offer $F(3,210) = 2.56$, $p = 0.056$, $\eta^2 = 0.035$. As illustrated in Figure 3.1, this interaction stemmed from group differences in the effects of the proposer manipulation, specifically on the £3 offer trials. Whilst TD participants rejected this offer significantly more often in the human ($M = 0.51$; $SD = 0.47$) than the computer condition ($M = 0.32$; $SD = 0.42$; $t(75) = 2.79$, $p = .009$;

Cohen's $d = 0.43$), ASD participants rejected this offer at an identical rate ($M = 0.47$; $SD = 0.47$) in both conditions, suggesting that the value of the offer rather than the nature of the proposer motivated the decision in this group.

Physiological data

For the analysis of GSR responses, we first examined the extent to which GSRs varied as a function of the value of the offers and the nature of the proposers. Because of the relatively small number of trials for each type of unfair offer, responses to offers of £1, £2 and £3 out of the £10 were averaged under an 'unfair' category for this analysis. It is important to note that 7 TD and 2 ASD participants needed to be excluded from this analysis because they had insufficient numbers of reliable GSRs above the $0.02\mu S$ threshold in all relevant conditions. The data for the remaining 29 TD and 34 ASD participants is set out in Figure 3.2 and did not replicate the observations of van 't Wout et al., (2006) in that there were no main effects or interactions (all $F_s < 1.7$; $p_s > 0.2$).

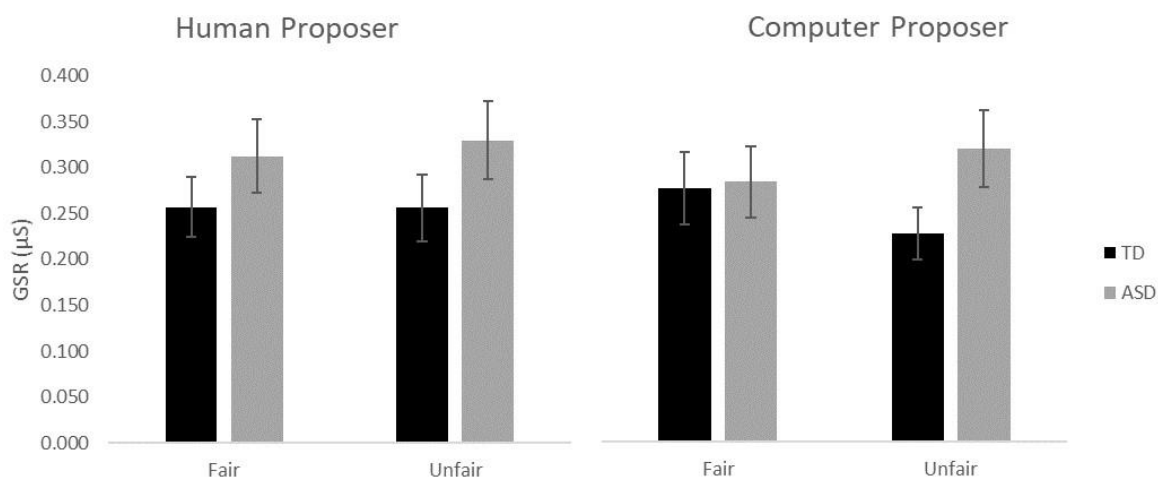


Figure 3.2 Average GSR amplitude in response to fair and unfair offers as a function of proposer (human vs. computer) and participant group (ASD vs. TD). Error bars indicate +/- 1 SE.

To examine whether GSR responses predicted whether offers would be accepted or rejected, the GSR data were also averaged across accepted and rejected offers in each of the two proposer conditions. Because not all participants accepted *and* rejected offers in each of the two proposer conditions relevant averages could not be calculated for 10 TD and 7 ASD participants in the human condition and for 16 TD and 15 ASD participants in the computer condition. Due to these unequal participant numbers, and to retain as many participants in the analysis as possible, two separate 2 (Group: ASD vs. TD) $\times$ 2 (Decision: Accept vs. Reject) ANOVAs were carried out for the two proposer conditions (Human vs. Computer) – the data are set out in Table 3.2. The only significant effect that emerged was a main effect of group in the human proposer condition $F(1,53) = 4.48$, $p = 0.039$, $\eta^2 = 0.078$), where the ASD group demonstrated overall greater GSRs. The absence of any other significant effects or interactions again fails to replicate the observations of van 't Wout et al., (2006) who had found that GSRs predicted rejection rates particularly for human offers.

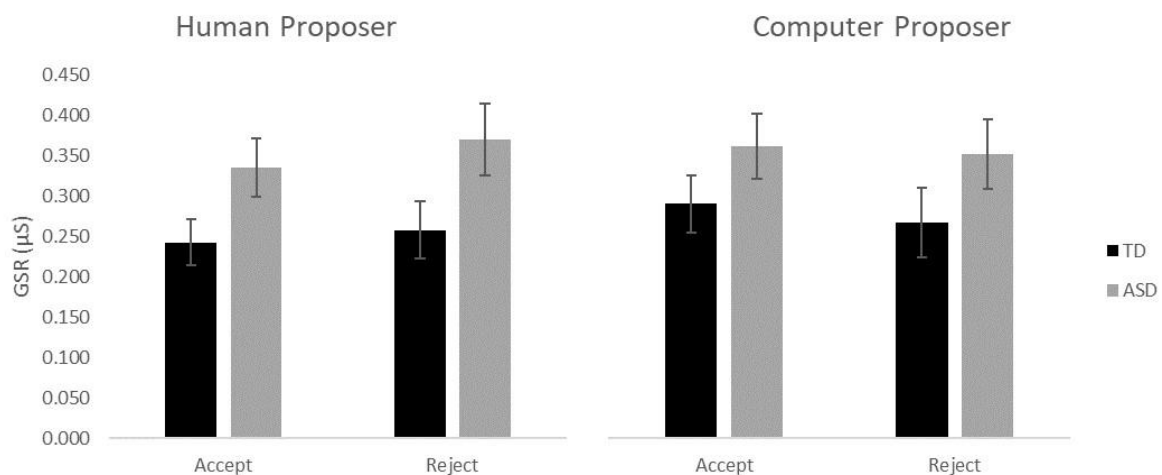


Figure 3.3 Average GSR amplitude for accepted and rejected offers as a function of proposer (human vs. computer) and participant group (ASD vs. TD). Error bars indicate ± 1 SE.

3.4 Correlations / Predictors of Decisions

Following the data analysis approach of Chapter 2, simple correlations were examined to identify individual difference factors that might correlate with participant's decision. Table 3.2 sets out the simple correlations (Pearson's r coefficients) between rejection rates of unfair human and computer offers and each of a number of individual difference factors of interest, including age, VIQ, PI, FIQ, AQ, RMIE, BIS/BAS and EPQ idealism and realism. Correlations are shown for both groups combined as well as for each group separately and r -coefficients greater than 0.3 are highlighted in bold for ease of reference (all of the highlighted correlations were significant at the $p < .05$ level except that between VIQ and human rejection rates in the ASD group where $p = .055$).¹⁸

¹⁸ Since rejection rate are affected by fairness levels, we correlated measures in Table 3.2. with rejection rate for each offer type independently and by group. The result showed that rejection of the critical split £(3-7) in the ASD group significantly correlated when the offer is made by human with VIQ (-0.49) and EPQ_Idealism (0.45) and also when the offer is made by PC (-0.39) and (0.52) respectively. However, in the TD group the correlation is with EPQ_Idealism (-0.37) and RMIE (-0.36) and only when offers are made by human proposers. While no correlations were observed in the TD group for offers coming from PC, in the ASD group rejection rate correlates when the offers are £2 (VIQ = -0.42; EPQ_Idealism = 0.45) and £1 (VIQ = -0.44; EPQ_Idealism = 0.48). No correlations were observed in the ASD group when offers were made by human proposer. In the TD group, when offers were made by human there was a correlation between rejection rate and EPQ_Idealism (£2: -.039); (£1: -0.57)

Table 3.2 Bivariate Correlations between individual difference factors and rejection rates of unfair offers from Human and Computer proposers

	ASD		TD		Combined groups	
	Human	Computer	Human	Computer	Human	Computer
Age	-0.02	-0.05	0.12	-0.04	0.06	-0.05
VIQ	-0.32	-0.44	-0.41	-0.24	-0.36	-0.36
PIQ	-0.15	-0.28	-0.18	-0.13	-0.9	-0.21
FIQ	-0.28	-0.44	-0.27	-0.24	-0.28	-0.35
AQ	-0.15	-0.15	0.02	0.1	-0.08	0
RMIE	0.08	-0.06	-0.22	-0.17	-0.03	-0.1
E-S	0.3	0.27	-0.05	0.03	0.13	0.12
BIS	-0.15	0.07	0.08	0.19	0	0.13
BAS	-0.16	-0.1	0.18	0.31	-0.12	0.06
EPQ_ideal	0.41	0.51	-0.28	0.15	0.17	0.39
EPQ_real	0.23	0.25	-0.04	-0.33	0.11	0.02

As Table 3.2 indicates, Verbal IQ and FIQ predicted rejection rates in both participant groups to a similar degree with higher VIQs predicting lower rates of rejection. Interestingly, the ethics position idealism scale also predicted rejection rates in the ASD group whereas no such relationship was apparent in the TD group. Fisher's r to z transformations indicated that the differences in these correlations were significant for the human proposer condition ($z = 2.67, p < .01$) but not the computer proposer condition ($z = 1.51, p = .13$), though it is worth noting that within each group the patterns of correlations did not differ between conditions¹⁹.

3.5 Discussion

This study had a threefold purpose. First, to establish whether the equivalent behavioural responses between ASD and TD participants observed in the one-shot UG of Chapter 2 would replicate in a multi-trial UG. Second, to further examine what role theory of mind processes play in UG decision making by manipulating whether offers are made by intentional agents (humans) or non-intentional machines (a computer). And finally, we

¹⁹ A correlation ($r = 0.38, p = 0.034$) was found between (E-S) and EPQ_i measures; and between VIQ and EPQ_i ($r = -0.40, p = 0.002$)

investigated whether TD and ASD differ either in physiological response to unfair offers or more importantly in the way emotional responses to offers, as reflected in GSR, guides decision behaviour in the UG.

In relation to the first two aims, the current study generally confirmed that ASD and TD adults are very similar in terms of rejecting unfair offers in the UG. As already explained in relation to the finding of chapter 2, this result is somewhat unexpected considering that certain characteristics of ASD, such as their tendency for systemizing rather than empathizing (Baron-Cohen, 2006; Baron-Cohen, 2009; Baron-Cohen & Belmonte, 2005) would lead to the prediction that autistic individuals would behave more ‘rationally’ in an economic sense, and accept offers on the basis of their face value rather than a consideration of a proposer’s motives, e.g. fairness considerations.

Importantly, however, the data from the current study did suggest that there are differences between ASD and TD participants in terms of how decisions are made on the UG. Although both ASD and TD participants were sensitive in their decision behaviour to the proposer manipulation (i.e., both groups rejected unfair human offers significantly more often than unfair computer offers overall), this effect was only apparent for the most unfair offers of £1 and £2 out of 10 in the ASD group but not in the £3 unfair offer. ASD’s respond to offers of £3 may indicate that although they differentiate between proposers, they implemented the same strategy, e.g. logical strategy, when deciding over the critical split. It is possible that in situations of borderline fairness, where there is a genuine dilemma between fairness and financial considerations, TDs are sensitive to contextual information which allows them to rationalise the offer and so accept it. No differences, in cooperation rate, were also reported by (Hill et al., 2004; Sally & Hill, 2006) in which participants were asked to interact with human and computer partners in a prisoner’s dilemma.

The effects of the proposer manipulation on participants' emotional and behavioural responses is not only of interest in relation to the role that emotions play in guiding decision behaviour but also in relation to the role of ToM. Again, the evidence in ASD (Baron-Cohen, 1995) would lead to the prediction that the proposer manipulation should have less effect on individuals with ASD compared to controls. The current data partially confirm this prediction. Participants from both groups, similarly rejected less unfair offers from computers compared to human proposers (Blount, 1995; Civai et al., 2010), however while TDs behaved this way across unfairness levels, ASD did not differentiate between proposers when the unfair offer represented about 60% of the pot. On the one hand, these results show that intentional (human proposer) and randomly generated (computer) offers differently impact UG decisions. This distinction is necessary not only for understanding the role of theory of mind mechanism in UG decision behaviour, but also it is useful if we are to identify the motives underlying UG decisions. Computer generated offers were significantly less frequently rejected than similar offers coming from humans, which can indicate that participants used rejection to convey a message, e.g. punishment. In line with the claim by Pillutla & Murnighan (1996) that anger at being presented with an unfair offer is better predictor of rejection than inequality itself, and Rand & Nowak (2013), who suggest that retaliation, in the form of rejection, is the intuitive UG response when the individual expects fairness but is treated unfairly. On the other hand, since ASD differentiate between unfairness levels, this suggests that their decisions were rather motivated by the value of the offer than by the nature of the proposer.

One curious finding in this study, as well as the original paper by van't Wout et al., (2006) is that both groups of participants rejected a substantial proportion of unfair offers from a computer. If rejections primarily serve to 'punish' unfair behaviours to uphold social norms or are in some other way related to social processes, one would expect virtually all offers from a computer to be accepted. The fact that unfair computer offers are also rejected at a

considerable rate might suggest that participants either engage social-cognitive processes automatically in situations that mimic what is normally a social interaction (e.g., because the values generated by computers are framed as ‘offers’), or decision behaviour is substantially influenced by the values (and in particular the inequity) of offers rather than what motivates them. These issues will be explored in further details in subsequent chapters. What is most important for the current chapter is that, broadly speaking, both ASD and TD participants rejected unfair offers from computers to a similar extent suggesting similar levels of ‘irrationality’ in this context.

In addition to the group differences concerning the proposer manipulation, correlation analyses also indicated that different psychological traits might be engaged by ASD vs. TD participants when making decisions. Specifically, in the ASD group the positive correlation between the ethics position measure and rejection rate, suggests that ASD participants might reject unfair offers primarily because they apply universal moral rules for judging the offer, further supported by the relation between the (E-S) and EPQ measures. On the other hand, TD responders appear less governed by such universal rules as indicated by the null correlation in this group with the EPQ measure.

Interestingly, although rejecters in both groups (ASDs and TDs) may be following a different heuristic, rejecters in both groups seem to be engaging their general cognitive resources to similar extents as suggested by the negative correlation between rejection rate and VIQ and FIQ in both groups. These associations suggest that acceptance of unfair offers is guided by a more deliberate, and resource intensive set of processes than rejections, which may be guided by more intuitive, processes, or other abilities not assessed in this experiment. What the nature of the processes might be that draw on general cognitive resources for acceptance is open to speculation. It may be that participants with greater ability are more able to inhibit an

automatically triggered rejection of unfair offers or they may be more likely to consider the decision they are faced with from a rational point of view.

Although the current study did not replicate the observations by van't Wout et al., in terms of a role of somatic markers in guiding rejections, that original study along with others set out in the introduction involving the Iowa gambling task, would lend support to the notion that rejections are guided by more automatic than deliberative processes (see also Baron et al., 2015; Knoch et al., 2006; Sutter, Kocher, & Strauß, 2003 for further discussions) and this distinction will be considered in more detail in the next chapter. First, however it is important to consider why the current observations may not have replicated those of Van't Wout et al., (2006) in terms of the role of somatic markers in guiding decision behaviour.

Van't Wout et al., (2006) found significantly higher GSRs for unfair vs fair offers, particularly in a human proposer condition. These results had extended early findings which had demonstrated a relationship between emotional arousal and decision making (Bechara et al., 1997; Loewenstein, 2000; Loewenstein, 1996; Sanfey et al., 2003), and thus broadly supported the 'somatic marker' hypothesis (e.g., Damasio, 1994), which argues that internal physiological signals, which represent the value of the potential consequences of our decisions, play a significant role in guiding behaviour. In the current experiment, the experimental manipulations appeared not to have any effects on participant's physiological arousal in either group, at least as operationalised in terms of GSR responses.

Unfair offers did not elicit greater physiological arousal than fair offers in either group of participants, irrespective of who the offers were made by (humans or computers). Interestingly, the current study is not the first not to replicate the observations of Van't Wout et al., (2006). Null results were also found in a previous similar study by Osumi & Ohira, (2009) with a sample of Japanese university students (20, 10 females). Similar to the current

study, the authors had also used a fixed inter-stimulus-interval (ISI) between trials, which as Osumi & Ohira suggested, may have resulted in habituation and reduced anticipatory effects on autonomic responses to offers. Unfortunately, that study had not come to light by the time the current paradigm was implemented and therefore future studies should seek to implement variable ISIs in case this is the critical factor. It is also possible, however, that participant related, rather than task related factors played a role in the differences in findings across studies. For example, the current sample of participants may have found the experimental task generally less emotionally salient and engaging and therefore the different offer values were not differentially arousing. However, the average GSR responses elicited in the current study, which ranged from around 0.25 – 0.35 μ S across the different conditions, are comparable to those reported in Van't Wout et al., (2006), suggesting that this is an unlikely reason for the discrepant findings. Another possibility is that GSR responses may not be a 'pure' measure of a somatic marker given that GSR levels also index action preparation in cognitive and motor tasks (Nagai et al., 2004; Patterson, Ungerleider, & Bandettini, 2002). Additionally, it is worth noting that because of the relatively small number of trials for each type of unfair offer, responses to offers of £1, £2 and £3 out of the £10 were averaged under an 'unfair' category for the GSR analysis and this may obscure subtler differences between responses to unfair and very unfair offers. Although our task design in this respect replicated that of van't Wout et al., (2006), it may be the case that this design is not powered enough to reliably detect the effects observed in the original study and therefore future studies may benefit from the inclusion of a greater number of trials and participants.

One finding of interest that did emerge from the GSR data is that responses tended to be generally higher in the ASD compared to the TD group, which parallels some earlier observations. For instance, De Martino et al., (2008) found that ASD participants showed higher GSRs than controls overall, in a decision-making paradigm in which choices the

participants made resulted in outcomes that were framed as either wins or losses. Although the two groups did not differ in their decision behaviours and the net gains they achieved, higher levels of GSR were observed in ASDs, which the authors suggested could be an indication of heightened anxiety in the ASD group. Moreover, the results of this study showed that physiological responses in ASD did not differentiate between trials on which decision outcomes were framed as either gains or losses, unlike in the comparison group who showed greater GSRs to losses than gains. De Martino et al., (2008) suggest that this may indicate that ASD participants take a more analytical approach during the gambling task, which aligns with the interpretation offered above concerning the relative insensitivity of ASD participants in the current study to the nature of the proposer, at least for the £3 offer condition.

To summarize, in the current study although the ASD group showed higher GSRs compared to the TD group specifically when offers were made by human proposer, not differences were observed in the overall rejection rate between ASDs and TDs. We observed however that different cognitive process seems to play a role in UG decisions and that levels of fairness triggered different responses and possible different processes. Since in both the current and first study, participants have had unlimited time to give their responses this may have potentially masked subtle group differences in what factors guide the kind of intuitive decision making that is common in day-to-day interactions. In the next study we use a time pressure manipulation to explore further the relation between intuition and UG-decision behaviour.

4 EXPERIMENT THREE: COGNITIVE MANIPULATION, CRT & TOM

In Experiment 1 and 2 the rejection rate to an unfair offer in the UG did not differ between people with and without a diagnosis of ASD. Both groups rejected unfair offers at approximately the same rate, and there was no evidence to suggest that they arrived at the rejection decisions through different decision-making processes. However, differences may have gone undetected because of the paradigms used so far. In the previous two studies there were few constraints on what processes participants could engage to arrive at their decisions. In particular, there were no time constraints on the decisions participants needed to reach leaving open the possibility that groups differ in the extent to which they may rely on fairly automatic and intuitive vs. more controlled and deliberative processes to reach decisions.

The present study sets out to address this issue by implementing a time pressure manipulation. Across many areas of psychological research, time pressure manipulations have been used to try to tease apart the relative contributions of automatic and intuitive vs. more deliberate and controlled processes to different domains of functioning. Imposing time limits on behavioural responses essentially limits the amount of information processing participants can engage in, which is thought to force them to rely on simple heuristics and habits to guide their behaviour, rather than more deliberative consideration of the possible pros and cons of different behavioural options. Time-pressure manipulations have been used to reveal many biases and stereotypes that often inform people's judgements and behaviours, ranging from implementation of simple strategies such as acceleration and information filtering to cope and adapt to time constraints (Ariely & Zakay, 2001, for a review) trading-off between quantity over quality of information (Kocher & Sutter 2006) to anchoring at an initial perceived information without making further updates in their judgments often leading to sub-optimal outcomes and systematic cognitive errors (Kahneman, Slovic, & Tversky, 1982). Of most

interest to the current thesis are studies that have examined the issue of time in the context of the UG.

One way in which research has examined the potential contribution of relatively quick and automatic, vs more controlled and deliberative processes to decision making in the UG has been through the examination of participant's response times. For instance, in an online experiment in which about five thousand students responded to a series of very unfair UG offers, Rubinstein (2007) compared the response times of participants who accepted vs rejected the offers with the prediction that shorter RTs would be associated with reject decisions. This prediction was based on the literature outlined earlier in Chapter 1 which suggests that reject decisions may be motivated, at least in part, by aversive emotions that are assumed to be triggered relatively automatically and subconsciously responses (Pillutla & Murnighan, 1996; Sanfey et al., 2003; van 't Wout et al., 2006). Contrary to predictions, however, Rubenstein (2007) observed no differences in the median RTs between acceptances and rejections of the unfair offers.

Interestingly, Knoch et al., (2006), around the same time, examined the timing of decision processes involved in reject and accept decisions in the UG by using Trans Magnetic Stimulation (rTMS). In this experiment, participants were presented with 20 offers generated either by a computer (10) or an anonymous partner (10) in a random order, whilst receiving rTMS stimulation over pre-frontal cortical regions that are known to be involved in deliberative executively controlled reasoning. The results showed that rTMS stimulation over a right pre-frontal cortical region led to significant increases in acceptances of unfair offers compared to control conditions. Moreover, these acceptances occurred at the same speed as participants typically accepted fair offers (around 4 seconds) compared to the 6-7 seconds that participants typically took to reject, suggesting that participants might intuitively be motivated to accept offers to maximise personal gains but that they often override this automatic tendency through

executive control processes that motivate rejection. On the basis of these observations, it would be expected that requiring participants to respond quickly in an UG scenario, might increase their acceptance of unfair offers.

Somewhat surprisingly, only one study to date appears to have employed a time-pressure manipulation to examine this issue. Sutter, Kocher & Strauß (2003) asked participants to respond to unfair offers either within a 10 second time-limit or within a relatively unlimited time window of up to 100 seconds over a number of trials. Contrary to what might be expected on the basis of the study by Knoch et al., (2006), Sutter et al., (2003) reported significantly more rejections under the time pressure condition, although this effect was observed only on the initial trials, after which no differences between acceptance and rejection rates were observed. It was concluded by the authors that once repetition comes into play the effects of time pressure disappear, presumably because responders have now had time to work out that it is more profitable to accept. Contrary to the conclusions by Knoch et al., (2006) therefore, this study by Sutter et al., (2003) suggests that rejections of unfair offers may be the more automatic response although it is important to note that a 10 second time-limit is unlikely to limit information processing to such an extent that deliberative reasoning is ruled out or even minimised.

The results from the above-mentioned studies does not provide very consistent clues to the possible influences of automatic vs more deliberative decision processes in guiding ultimatum game decisions, possibly because the time-pressure manipulation employed by Sutter et al., (2003) may not have been as effective in reducing the influences of deliberative decision processes as the rTMS method by Knoch et al., (2006), and possibly because neither of the two studies considered the possible influences of individual differences in information processing and cognitive styles. Specifically, certain self-report measures such as the Thinking Inventory and the Rational-Experiential Inventory (REI; Epstein et al., 1996), suggest that

people differ in the extent to which they engage in automatic, intuitive thinking (experiential thought) and effortful, analytic thinking (rational thought).

Evidence from a web-based UG by Mussel et al., (2013) suggest that individuals who score high on a need for cognition index (18-item assessment of NFC: Cacioppo, Petty, & Kao, 1984) are more likely to naturally seek, acquire, think about, and reflect back on information to make sense of stimuli, relationships, and events in their world. Whereas individuals who score low in this measure are more likely to search for information in others, rely on cognitive heuristics, or social comparison processes. Participants were required to make UG-decisions within 3 seconds, which falls within the time-frame that the rTMS study by Knoch et al., (2006) had suggested as the period of relatively intuitive and automatic decision processes. The results indicate that longer reaction time and high scores in the NFC test were associated with higher rejection of unfair offer.

According to dual processing theories, (Evans & Stanovich, 2013) individuals, by default, rely on processing mechanisms of low computational expenses and come up with solutions to problems that at first seem to be optimal even if they are not. These initial response tendencies can thus be overridden to improve accuracy and more stable and self-beneficial choices. Evidence from the Cognitive Reflection Task (3i-CRT; Frederick, 2005; 7i-CRT; Toplak, West, & Stanovich, 2014) suggest that the tendency to follow a deliberative approach after over-riding the tendency to accept an intuitive and fast solution, varies in the population, and different time demands are observed between individuals who follow one or the other approach.

All in all, the evidence outlined above suggests that intuitive vs. more deliberative processes do contribute uniquely to driving decisions that are either self-serving or fairness preserving, depending on certain individual trait characteristics. On balance, the evidence

outlined above, appears to favour the notion that people might intuitively lean toward accepting unfair offers due to a relatively automatic drive toward maximizing personal gain (e.g., Koch et al., 2006). On the other hand, some of the evidence outlined in the previous chapter also lends support to the idea that rejections may be motivated by relatively automatic and emotion-related processes in terms of aversive responses to unfairness (e.g., Pillutla & Murnighan, 1996; Sanfey et al., 2003; van 't Wout et al., 2006). Cutting across these possibilities there is also evidence suggesting that individual difference characteristics may have strong influences over the biases that individuals display in decision-making contexts. Some of these individual difference factors (e.g., BIS vs. BAS tendencies) were examined in the previous chapters and the current chapter will extend this by taking into consideration cognitive styles.

Evidence on reasoning styles in ASD is relatively scarce but, as outlined in the literature review in chapter 1, a number of recent studies by Brosnan and colleagues suggest that autistic individuals may demonstrate a greater tendency for deliberative vs. more intuitive reasoning than comparison participants. For instance, Brosnan, Chapman, & Ashwin, (2014) examined decision making in ASD and comparison groups in the 'Jumping-to-Conclusions Beads Task'. The task involves two jars filled up with different sized beads. One jar is filled up with 60 black beads and 40 white beads, and a second jar contains 40 black beads and 60 white beads. One jar is chosen, and beads are then drawn and shown to participants one at a time. After each bead participants had to make a decision about which jar they thought the beads from (i.e., the one with more black or white beads), or else ask for another bead to be drawn until they make a decision. It was found that compared to the control group, ASD adolescents requested more data before making decisions. This information style, labelled by the authors as "circumspect reasoning" (Brosnan et al., 2014, page 517) has parallels with a systemizing profile as described by the E-S theory outlined in Chapter 1 (Baron-Cohen, 2009), whereby ASD is characterised by a drive to discover the rules governing a certain situation or system, which would be a fairly

resource intense and deliberative process. In a subsequent study, Brosnan et al., (2016a) further extended this evidence through data collected on the CRT (Frederick, 2005) and REI (Epstein et al., 1996) described above. Higher accuracy in the CRT and low self-reported intuition in the REI in the ASD group, supported the notion that ASD is characterised by a bias toward deliberative reasoning (Brosnan et al., 2014).

Together, the evidence outlined above leads to the prediction that autistic individuals would be more reliant on deliberative processes to arrive at their decisions in the UG than comparison groups. What the precise consequences of this would be on the decision behaviours is not entirely clear due to the uncertainty that remains over whether acceptance or rejection is the more intuitive and automatic response. As noted above, whilst the evidence might lean toward suggesting that acceptance due to self-serving biases might be the default and automatic response, this likely depends on certain characteristics of the individual, making it difficult to make predictions at a group level. Nevertheless, it is generally accepted that a combination of intuitive and more deliberative processes is at work in the UG and that time pressure would generally disrupt deliberative processes. Thus, whatever the automatic response, if autistic individuals rely more on deliberative processes, a time-manipulation should have greater influences on their behaviour than in comparison participants, whether at a group level or an individual level. The current study will examine this prediction by implementing a time-pressure manipulation whilst measuring individual differences in cognitive style through the Cognitive Reflection Task, hereafter 7i-CRT (Toplak et al., 2014), along with some other individual difference characteristics as in the previous studies (e.g., RMIE, E-S,BIS/BAS, EPQ_Relativism and EPQ_Idealism). Compared to previous studies examining the effects of time-pressure on the UG, the current study will also make use of certain control tasks that will serve to illustrate that the time-pressure manipulation is effective in disrupting certain deliberative processes that may play a role in informing UG decisions.

4.1 Method

Participants

Sixty adults took part in this study: Thirty individuals with a diagnosis of ASD (24 male; 6 female) and 30 typically developed comparison individuals (17 male; 13 female). Participants were recruited from an existing database at City, University of London. They were paid a standard University fee of £8 per hour for their participation plus the earnings from the Ultimatum Game, as described below. ASD participants had been diagnosed with Autism Spectrum Disorder by clinicians through the UK's National Health Service (NHS) according to DSM-IV criteria. Assessment in the lab with the Autism Diagnostic Observation schedule (ADOS; Lord et al., 2012) by a researcher trained to research reliability standards on the instrument, provided further corroboration of their diagnosis. Typical individuals were selected to match ASD participants on chronological age, verbal IQ, performance IQ, and full-Scale IQ as measured by the Wechsler Adult intelligence scale (WAIS-IV^{uk}; and WAIS-III^{uk}). All participants completed the AQ (Baron-Cohen et al., 2001) which provided further evidence for the diagnosis of ASD in the clinical group and ruled out that the TD group included participants who may be experiencing the kind of social communicative and cognitive difficulties that are commensurate with autism. The descriptive statistics for these variables are summarised in Table 4.1. None of the TD participants reported having a personal or family history of a psychological or neurodevelopmental disorder.

Table 4.1 Characteristics for autistic individuals (ASD) and Typically Development Individuals (TD)

	ASD (24m,6f)		TD (17m,13f)				
Measure	M (SD)		M(SD)		<i>t</i> (59)	<i>P</i>	Cohen's <i>d</i>
Age (years)	47.23	(12.91)	52.27	(15.17)	1.38	0.17	0.35
^a VIQ	111.76	(19.12)	113.37	(12.79)	0.37	0.70	0.09
^b PIQ	106.43	(19.97)	111.32	(15.42)	1.03	0.30	0.27
^c FIQ	110.86	(20.37)	113.18	(13.40)	0.50	0.61	0.13
^d AQ	34.06	(7.58)	14.39	(6.05)	10.80	< 0.001***	2.28
^e ADOS-C	2.96	(1.62)					
^f ADOS-RSI	5.66	(2.63)					
^g ADOS-Total	8.62	(3.78)					

^a Verbal IQ (WAIS-III^{UK} or WAIS IV^{UK}); ^b Performance IQ (WAIS-III^{UK} or WAIS IV^{UK}); ^c Full Scale IQ (WAIS-III^{UK} or WAIS IV^{UK}); ^d Autism Spectrum Questionnaire (Baron-Cohen et al.,2001); ^e ADOS- Communication; ^f [In brackets range of scores for ADOS]; ^f ADOS- Reciprocal Social Interaction; ^g ADOS Total Score- Communication + Reciprocal Social Interaction.

Materials & Design

The stimuli for the current experiment included 24 monetary offers that varied in terms of the overall pot sizes to which they related and, also in terms of the level of fairness, as shown in Table 4.2. Diverse offers were chosen to increase the number of trials per participant and to encourage them to consider each split independently rather than habituating to the same offers over the experimental session. Pot sizes ranged from £5 to £30 and the fairness of the offers varied across four categories [Category 1: (50% - 50%); Category 2: (40 - 60%); Category 3: (25 - 75%); Category 4: (20 - 80%)], with the first value indicating the percentage of the pot that was to go to the person receiving the offer (e.g. 40%), and the second value indicating the percentage of the pot that the person making the offer was to retain for himself (e.g. 60%). Thus, the fairness decreases across the four levels. In the forthcoming pages for brevity and to remind the reader about the distribution of the money, the games were labelled in this format: C50, C40, C25, C20, where C stands for *fairness category*, and the number represents the percentage of money going to the responder, with C20 representing the least fair split. To maintain a high degree of ecological validity within the task, three of the twenty-four offers

were ‘real’ offers that had been made in the first study of this research project. Participants were informed about this (see procedure section), but they could not distinguish these real offers from fictitious ones that were purposefully generated for the task. Participants were told that 10% of the value of the real offers would be paid out according to the rules of the ultimatum game to both, proposers and responders.

Table 4.2 Splits by Fairness category

Pot size	Fairness category	For You	I keep
£10	C50	£5	£5
£12	C50	£6	£6
£14	C50	£7	£7
£16	C50	£8	£8
£18	C50	£9	£9
£20	C50	£10	£10
£5	C40	£2	£3
£10	C40	£4	£6
£15	C40	£6	£9
£20	C40	£8	£12
£25	C40	£10	£15
£30	C40	£12	£18
£8	C25	£2	£6
£12	C25	£3	£9
£16	C25	£4	£12
£20	C25	£5	£15
£24	C25	£6	£18
£28	C25	£7	£21
£5	C20	£1	£4
£10	C20	£2	£8
£15	C20	£3	£12
£20	C20	£4	£16
£25	C20	£5	£20
£30	C20	£6	£24

Participants played the role of responder throughout the experiment and were therefore asked to decide whether to accept or reject each offer in a mixed subjects design: 2 (Group: ASD vs. TD) x 2 (Fair vs. Unfair offers) x 2 (Time pressure vs. No time pressure). The time pressure factor was manipulated within subjects and therefore all participants were presented with the same offers twice, once under the time-pressure condition and once under the no-time pressure condition (hereafter untimed). The order of the conditions (time pressure vs. untimed) was counterbalanced such that an equal number of participants in both groups completed either the time pressure or the untimed condition first. Offers were presented in a random order on a computer screen in the format “*Luke offers £2 and keeps £8*”. Names were randomly paired with offers.

During the untimed trials, participants were given an unlimited amount of time to respond to the offer. Thus, the offer remained on the screen until the participant either pressed the ‘*a*’ key on the keyboard to accept or the ‘*r*’ key to reject. During the time pressure trials, on the other hand, participants needed to respond within 2000 milliseconds. A timer on the top of the screen provided a visual countdown of the remaining time. If participants failed to respond within the 2000ms time-limit a red frame appeared around the screen that indicated to participants that the time had elapsed and that this trial would not be paid out – their response, however, was still required to progress to the next trial. This set up ensured that we could obtain response data from all trials. The 2000ms duration was primarily informed by pilot testing, which suggested that, in the current paradigm, participants typically responded within 2-3 seconds when no time pressure was imposed (see also the results presented in Table 4.5 below). After participants gave their response, a 1000ms screen with a central fixation cross was presented before the next offer appeared.

Mathematical task

In addition to the UG task, an equivalent mathematical task was also designed as a control condition to confirm that the time-pressure manipulation does, indeed, influence deliberative cognitive processes of the kind that are likely to be relevant to decision making in the UG. Participants always completed the arithmetic task after the UG task because it included the same stimuli and it was important not to contaminate responses on the UG with possible practice or other carry-over effects from the arithmetic task. The arithmetic task was identical to the UG task except that participants now needed to decide whether the amount of money offered to them was less than 30% of the total pot. As with the UG, these decisions needed to be made in both conditions; under and without time pressure. The order of these conditions was again counterbalanced across participants. Accuracy on this task was financially rewarded with £0.50 per response within the time limit to incentivise this task in a similar fashion to the main UG task.

The CRT, Theory of Mind (RMIE), E-S, BIS/BAS, EPQ Relativism, EPQ Idealism

A computerized version of the 7i-CRT was implemented (Toplak et al., 2014), which is an extension of the original three item test developed by Frederick (2005). An example of the questions included in the task is: *A bat and a ball cost \$1.10 in total. The bat costs a dollar more than the ball. How much does the ball cost?* The intuitive response is 0.10 cents, but the right response is 0.05 cents. A response could be scored as 1 (for the correct response) or otherwise zero. Higher scores, therefore, are indicative of a more ‘reflective’ person. Although the measure is widely known, all seven questions and responses can be found in Appendix A. Responses distinguish between intuitive and wrong answers to aid the reader when looking at the results and the analysis. The RMIE (Baron-Cohen et al., 2001) and the other measures were

administered to each participant, unless results on this task were already available on file for a participant.

All in all, the testing session lasted about one hour and a half, including time for instructions and breaks between the UG and the CRT. Apart from performance in the ToM task, performance was rewarded in all other tasks to keep the incentives relatively constant across all measures. Payment was arranged at the end of the session. For the UG a responder who accepted all the real splits received £4.40; accuracy in the mathematical task gave a maximum of £2.40; accuracy of the CRT represented additional £2.10 in total (£0.30 per correct response). Participants received a standard £8 per hour and the cost of transport to come to the Lab was also reimbursed.

Procedure

Participants were individually tested in one of the dedicated laboratory rooms of the Autism Research Group at City, University of London. They were told that they would be taking part in a decision-making task that would require them to make financial decisions about certain monetary offers under several conditions.

An information sheet explained the rules of the UG game although the name of the game was not mentioned. Participants were informed that the task was to be completed several times, interacting anonymously with a different a proposer in each occasion, who also had the same information about the rules for the interaction. Participants were informed that the role of proposer and responder were assigned by the experimenter, decision had already been made by proposers, and they have been assigned the role of responders. They were also told that not all but some of the offers were real and taken from a previous study in the Lab, yet real offers were not distinguishable. They were informed that out of the total of accepted real offers, both, responders and proposers would be paid 10% of the total of the values in the distribution. The

number of trials was not specified. Once participants confirmed that they understood the task and gave their written consent to proceed, they first completed the two conditions of the UG, followed by the two conditions of the arithmetic task and finally they completed the CRT and, if not already available, the reading the minds the eyes task.

At the beginning of each of the four experimental tasks (i.e., the timed and untimed UG and timed and untimed arithmetic tasks), participants first saw a number of screens with the specific instructions for the condition they were about to complete. For the UG participants saw the following:

Before presenting you with the offers, there will be a few practice trials. Some of these trials will be with a time limit, and some without. For trials with a time limit a clock will be shown on the top of the screen. In these practice trials, you will simply see either a word or a non-word on the screen and you should press 'w' for a word or 'n' for a non-word. Press SPACE for the practice trial.

Eight practice trials were presented to familiarize participants with the general structure of the task and, also with the duration of the time limit that would be imposed for some trials during the UG. After the practice trials, the instructions continued as follows:

Now you will be presented with the offers for you to decide. Some of these decisions need to be made within a limited amount of time and some without. For trials with a time limit a clock will be shown on the top of the screen. When you accept an offer, you will receive 20% of the value offered to you and the other person will receive 20% of the value they have chosen to keep for themselves. Remember to press "A" for acceptance and "R" for rejection. You are now ready to begin the task.

If the block corresponded to a time pressure condition, participants received a prompt to say that *“For the next set of offers you will only have a limited amount of time to make your decision”*, and otherwise the start of block instructions read *“Consider the next offers as long as you wish before responding”*

For each UG trial, participants then saw the name of the proposer on the top middle part of the screen. Right below, in one line, the proposed amounts were displayed in the format *“offers £3 keeps £7”*. Below, in a third line the words *“Accept or Reject?”* were presented. The keyboard was covered so only the needed letters for this task were available to participants. Under the time pressure condition, the countdown timer was also presented above the name of the proposer.

Between the UG and arithmetic tasks participants took a brief break to allow the experimenter to prepare the next block of trials. The following instructions were presented for the arithmetic task: *You will be presented with the same offers you received in the previous session. This time we would like you to say for each trial, whether the amount offered to you is less or more than 30% of the total pot. Type "L" if the amount offered to you is less than 30%. Type "M" if the amount offered to you is more than 30%. Some of these calculations need to be made within a limited amount of time and some without. For trials with a time limit a clock will be shown on the top of the screen. You will be paid £0.05 for each accurate calculation.* For each of the trials, *“Is the offer less than 30% of the total pot?”* was presented on the response sheets with *“Less or More”* replacing the Accept/Reject decision prompts. The rest of the procedure remained the same as in the UG.

The computer program was set up to guide participants through the experiment in the absence of the experimenter. At the end of each task, the screen showed *“Thank you for taking part in our experiment. Please let the experimenter know you have finished by pressing the*

ENTER key. Please open the door to let the experimenter in”. The program was set up to show the earning only at the end of the testing session, “*You have won £[money]*”

For the 7iTask, the program presented one question at the time. All participants received the questions in the same order and there was not time pressure at any time. On the first screen, they saw “*Welcome. You are about to start the task. Please press the SPACEBAR to continue*”; the second screen “*You will be presented with some questions for you to respond. Type your answer and use the enter key to move on to the next item. You will have received £0.30 for each correct response. Please press the SPACEBAR to continue*” and this was the same for all seven questions.

4.2 Results

Ultimatum Game

Under time pressure participants violated the time limits an average of 1.6 out of 24 trials, indicating that approximately 99% of the decisions were made within the time limits. Since exclusion of the trial on which participants responded outside the time-limit did not alter the pattern of results reported below, all trials were retained in the analyses. Collapsing offers across groups and time condition, as expected fair offers were mostly accepted, with an 11% resulting in rejections. On the other hand, 66% of the unfair offers were rejected. The average rejection rates for ASDs and TDs as a function of Time and Fairness Category can be found in Table 4.3.

Table 4.3 Average Rejection Rate by Group, Fairness category and Time condition

Timed	ASD		TD		Both groups	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
C50	0.04	0.08	0.08	0.19	0.06	0.15
C40	0.23	0.35	0.17	0.25	0.20	0.31
C25	0.58	0.41	0.58	0.37	0.58	0.39
C20	0.68	0.39	0.72	0.27	0.70	0.33
Overall	0.38	0.42	0.39	0.39	0.39	0.40
Untimed						
C50	0.01	0.04	0.03	0.13	0.02	0.10
C40	0.19	0.32	0.11	0.20	0.15	0.27
C25	0.60	0.43	0.61	0.38	0.61	0.40
C20	0.72	0.39	0.79	0.27	0.76	0.34
Overall	0.38	0.44	0.39	0.44	0.38	0.43

A 2 (Group: ASD vs TD) x 2 (Time: time pressure vs untimed time) x 4 (Fairness category: C50 vs C40 vs C25 vs C20) mixed factor ANOVA with repeated measures in the last two factors was carried out to examine whether rejection rates differed across groups, unfairness of the offers, and time pressure. There was no main effect of Time, $F(1,58) = 0.007$, $p = 0.93$, $\eta^2 = 0.00$ but the analysis yielded the expected main effect of Fairness category²⁰ $F(2.08,120.72) = 123.33$, $p < 0.001$, $\eta^2 = 0.68$ with rejection rates increasing as the fairness of offers decreased. Bonferroni pairwise comparisons showed that participants rejected offers more often in category C20 ($M = 0.73$, $SD = 0.33$) than in category C25 ($M = 0.59$, $SD = 0.39$), more often in category C25 compared to category C40 ($M = 0.18$, $SD = 0.29$) and more often in category C40 compared to category C50 ($M = 0.04$, $SD = .12$; all $ps < .001$).

The analysis also yielded an interesting significant interaction between Time and Fairness Category $F(2.64,153.08) = 5.56$, $p = 0.002$, $\eta^2 = 0.09$, which is illustrated in Figure

²⁰ Homogeneity not assumed, Levene's task < 0.050 . In C50 & C40 (Timed) and in C40 for the untimed condition, then $F(1,120) = 123$, $p < .001$, $\eta^2 = .68$. Greenhouse Geisser correction were used.

4.1. To resolve this interaction, simple main effects were analysed by looking at the effect of Time at each level of Fairness Category across both participant groups.

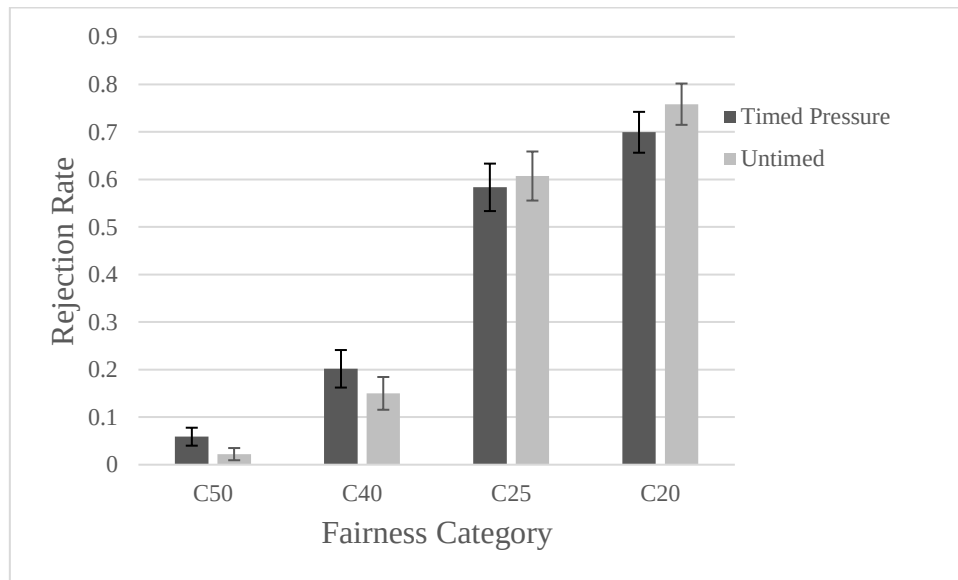


Figure 4.1. Rejection rates as a function of Time and Fairness Category.

Paired sample t-tests with Bonferroni adjusted alpha levels of .0125 (.05/4) showed marginally higher rejection rates under time pressure ($M = 0.06$, $SD = 0.15$) than in the untimed condition ($M = 0.02$, $SD = 0.100$) for the fairest offers of C50, ($t(59) = 2.31$, $p = 0.024$, Cohen's $d = 2.74$), and also significantly higher rejection rates under time pressure ($M = 0.20$, $SD = 0.31$) than when untimed ($M = 0.15$, $SD = 0.27$) for the next fairest offers of C40, ($t(59) = 2.82$, $p = 0.006$, Cohen's $d = 0.17$). However, for the unfair offers of C25, ($t(59) = 0.83$, $p = 0.41$) and C20 ($t(59) = -1.83$, $p = 0.072$) there was no effect of Time.

The absence of a main effect of Group ($F(1,58) = 0.01$; $p = 0.92$; $\eta^2 = 0.00$) or any interactions including the group factor ($F_s < 0.82$, $p_s > 0.40$; $\eta^2_s < 0.02$) suggested that there were no overall group differences in rejection rates and that the experimental manipulations had similar effects for ASD and TD participants.

It is important to note that accuracy in the mathematical task, which will be explained in the next section, was correlated with ultimatum game rejection rate. Specifically, mathematical performance in the untimed condition correlates with overall rejection rate ($r = -0.33, p = 0.011$), with rejection rate in the time pressure ($r = -0.33, p = 0.009$), and in the untimed condition ($r = -0.29, p = 0.025$). Therefore, to control for mathematical abilities, in the above analysis, mathematical accuracy in the untimed condition was included as a covariate.

There was an effect of mathematical accuracy $F(1,57) = 6.959, p = 0.011, \eta^2 = 0.10$. As in the previous analysis, there was no effect of time $F(1,57) = 0.664, p = 0.42, \eta^2 = 0.012$. Similarly, there was an effect of fairness category, $F(2.06, 117.54) = 13.191, p < 0.001, \eta^2 = 0.18$. However, the interaction between Time and Fairness disappeared when controlling for mathematical accuracy $F(2.64, 150.62) = 0.043, p = 0.99, \eta^2 = 0.00$. There was no effect of group or any interaction including the group factor ($F_s < 1, p_s > 0.50, \eta^2 < 0.014$).

Mathematical task (Control condition)

Accuracy on calculating the percentage of the total pot offered as a function of Time and Fairness Category for ASDs and TDs can be seen in Table 4.4

Table 4.4 Accuracy on calculating the offered percentage as a function of Time and Fairness Category for ASDs and TDs

	ASD		TD		Both groups	
Timed	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
C50	0.77	0.28	0.84	0.26	0.80	0.37
C40	0.67	0.32	0.71	0.33	0.69	0.33
C25	0.62	0.37	0.47	0.26	0.54	0.33
C20	0.68	0.34	0.72	0.32	0.70	0.32
Overall	0.68	0.33	0.68	0.29	0.68	0.31
Untimed						
C50	0.87	0.28	0.92	0.20	0.89	0.24
C40	0.82	0.32	0.96	0.16	0.89	0.26
C25	0.64	0.37	0.56	0.38	0.60	0.37
C20	0.90	0.27	0.96	0.13	0.92	0.21
Overall	0.80	0.31	0.85	0.22	0.83	0.27

A 2 (Group: ASD vs TD) x 2 (Time: time pressure vs untimed) x 4 (Fairness category: C50 vs C40 vs C25 vs C20) mixed factor ANOVA with repeated measures on the last two factors was run to see whether participants' accuracy on the mathematical task would differ depending on Group membership, Fairness category, and whether participants did the calculations under time pressure or not. The analysis yielded no main effect of Group, $F(1,58) = 23, p = 0.63, \eta^2 = 0.00$. However, unlike in the UG task, the analysis revealed a robust effect of Time $F(1,58) = 23.67, p < 0.001, \eta^2 = 0.29$, with more accurate performance during the untimed ($M = 0.83, SD = 0.27$) than the time pressure condition ($M = 0.68, SD = 0.31$). There was also a main effect of Fairness category $F(1.98,114.69) = 21.13, p < 0.001, \eta^2 = 0.27$, with significantly poorer performance on C25 fairness trials ($M = 0.57, SD = 0.27$) compared to C50 ($M = 0.85, SD = 0.25; p < .001$), C40 ($M = 0.79, SD = 0.29; p < 0.05$) and C20 ($M = 0.81, SD$

= 0.27; $p < 0.001$), which is expected given that in C25 trials the offers were closest to the 30% that participants needed to calculate for their response. Finally, there was also a Fairness category x Group interaction $F(1.98, 114.69) = 3.15$, $p = 0.047$, $\eta^2 = 0.05$ ²¹, which is illustrated in Figure 4.2. Separate 2 (Time: time pressure vs. untimed) x 4 (Fairness category: C50 vs. C40 vs. C25 vs. C20) mixed factor ANOVAs showed significant main effects of Fairness category for TDs, $F(1.93, 56.04) = 24.41$, $p < .001$, $\eta^2 = .46$, as well as ASDs $F(1.84, 53.54) = 3.75$, $p = .03$, $\eta^2 = .11$. However, Bonferroni pairwise comparisons showed that whereas TDs were significantly more accurate in C50 ($M = 0.88$, $SD = 0.21$), C40 ($M = 0.83$, $SD = 0.18$), and C20 ($M = 0.83$, $SD = 0.18$) compared to C25 ($M = 0.51$, $SD = 0.26$; all $ps < .001$), ASDs were more accurate in C50 ($M = 0.81$, $SD = 0.24$) and C20 ($M = 0.78$, $SD = 0.27$) compared to C25 ($M = 0.63$, $SD = 0.31$, both $ps = 0.007$) with no differences between the C40 and any of the other categories. In other words, as illustrated in Figure 4.2, the performance of ASD participants was relatively more even across the four fairness categories, compared to the TD group.

²¹ Not homogeneity assumed for C25 (Under time pressure) and for Categories C40 and C20 under Not Time pressure.

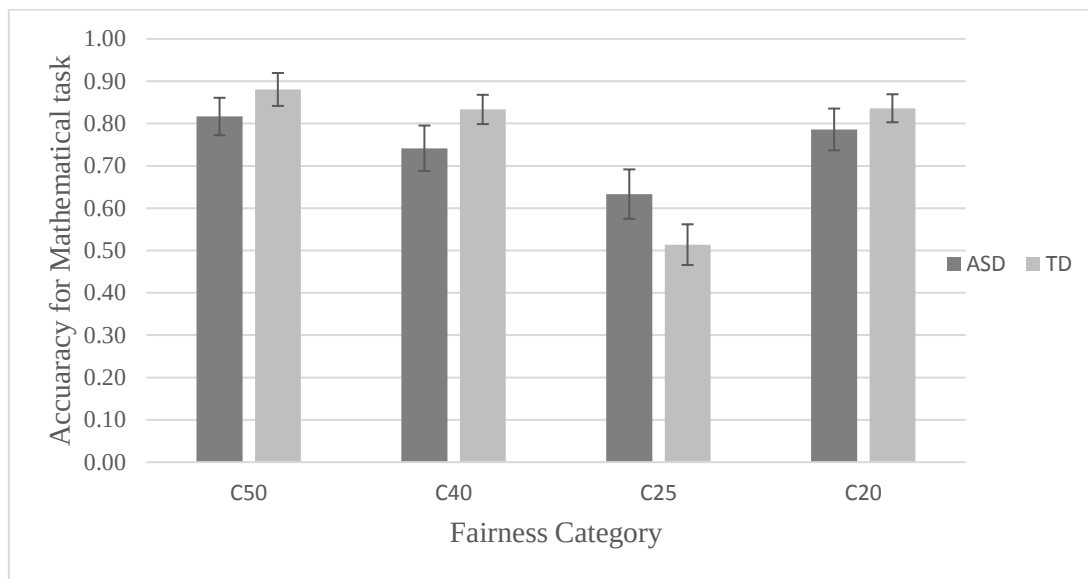


Figure 4.2 Fairness by Group interaction in the mathematical task

The ANOVA on the performance data from the mathematical task also yielded a significant Time x Fairness category interaction, $F(3,174) = 6.00$, $p = 0.001$, $\eta^2 = 0.094$. Simple main effects were analysed by looking at the effect of Time at each level of Fairness Category using Bonferroni adjusted alpha levels of .0125 (.05/4). This analysis showed no significant main effect of Time on accuracy for C25 ($p = 0.23$), where performance was overall poorest and relatively close to chance, see Figure 4.3. However, for categories C20, C40 and C50 the analysis yielded a significant difference in accuracy when participants respond under time pressure or not.

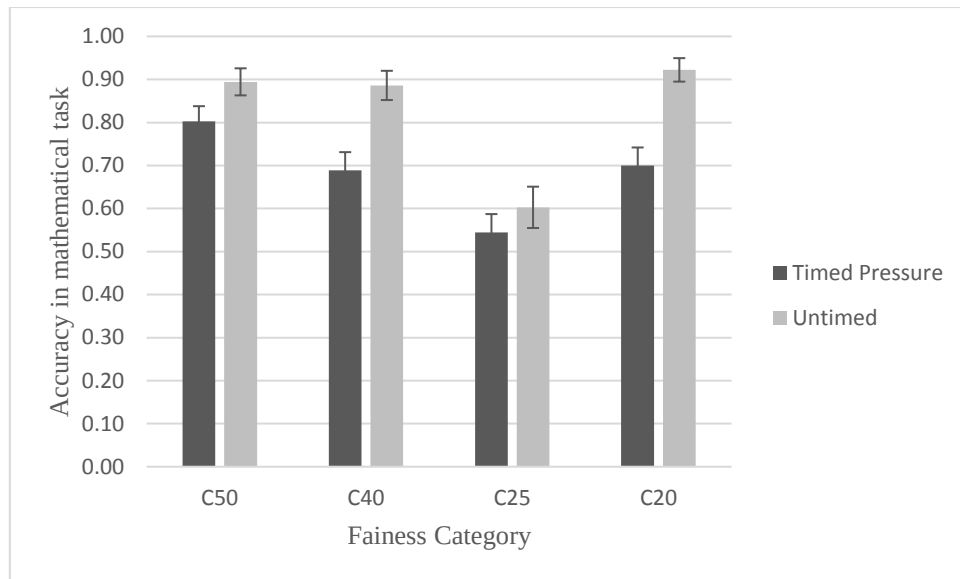


Figure 4.3 Accuracy in the Mathematical Task as a function of Time and Fairness Category.

Reaction Time

Reaction time for responder behaviour in the UG

The average reaction time for rejection rate for ASDs and TDs as a function of Fairness Category and Time condition can be found in Table 4.5. The inspection of the data revealed one missing data point representing a participant who accepted all offers, which meant that no reaction time data was available for rejections.

We ran the same ANOVA analyses as described above but using participants' response time to make rejections as a dependent variable to see whether reaction times differed depending on Group, fairness of the offers, and whether decisions were made under time pressure or not. A 2 (Group: ASD vs TD) x 2 (Time: time pressure vs untimed) x 4 (Fairness category: C50 vs C40 vs C25 vs C20) mixed factor ANOVA with repeated measures on the last two factors yielded no main effect of Group, $F(1,58) = 0.81$, $p = 0.37$, $\eta^2 = 0.014$.

Table 4.5 Average Reaction Time for UG response by Group, Fairness category and Time condition

	ASD		TD		Both groups	
Timed	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
C50	956.85	256.65	1108.09	232.84	1032.47	254.64
C40	125.94	333.89	1268.83	230.53	1197.39	293.45
C25	1153.59	315.95	1319.68	265.60	1236.64	301.26
C20	1108.83	304.98	1322.55	263.52	1215.69	302.43
Overall	1086.30	302.87	1254.79	248.12	1170.55	287.95
Untimed						
C50	1974.57	1134.85	2290.22	1676.70	2132.39	1428.36
C40	2906.26	2101.78	2820.97	1415.15	2863.00	1776.94
C25	3226.29	2649.79	3465.43	2083.30	3345.86	2366.23
C20	2823.36	1654.55	3159.83	1814.21	2991.59	1729.78
Overall	2732.62	1885.24	2934.11	1747.34	2833.21	1825.33

However, there was a significant main effect of Time, $F(1,58) = 82.37, p < 0.001, \eta^2 = .58$, confirming that – unsurprisingly – participants responded faster under time pressure ($M = 1170.55, SD = 287$) than in the untimed condition ($M = 2883.37, SD = 1825$). Also, there was a main effect of Fairness category, $F(2.21,128.18) = 12.39, p < 0.001, \eta^2 = .18$. Bonferroni pairwise comparison showed no significant differences in reaction time between C40 and C25, C25 and C20, and between C20 and C40. However, participants were faster in C50 ($M = 1582.43, SD = 841$) compared to all other categories (C25: $M = 2291, SD = 1333; p < 0.001$; C20: $M = 2103, SD = 1016; p < 0.001$; and C40: $M = 2030, SD = 1035; p = .003$), suggesting that participants required very little time to judge and decide over egalitarian offers.

In addition, the analysis yielded a significant Time x Fairness category interaction, $F(3,174) = 6.26, p < 0.001, \eta^2 = 0.097$. To resolve this interaction, two repeated measure ANOVAs were carried out to examine the effects of Fairness category at each level of Time. These analyses yielded significant main effects of Fairness category under the time pressure, $F(3,177) = 35.27, p < 0.001, \eta^2 = 0.37$, and no time pressure condition, $F(3,177) = 9.26, p <$

0.001, $\eta^2 = 0.136$, however with a visibly less pronounced effect of fairness category in the time pressure condition (see Figure 4.4).

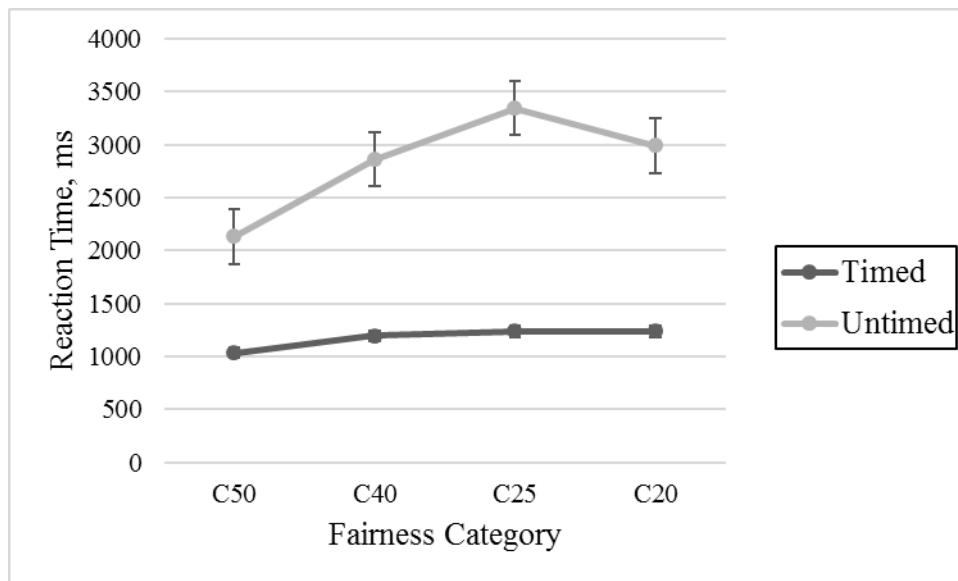


Figure 4.4 Mean Reaction time to respond to UG offers as function of Fairness category and Group for Timed and Untimed trials. *Error bars in the Timed condition are smaller than the width of the data-point markers on that line

Reaction time for Mathematical task

The average response times for the mathematical calculations for ASDs and TDs as a function of Fairness Category and Time condition can be found in Table 4.6. A similar 2 (Group: ASD vs TD) x 2 (Time: time pressure vs untimed) x 4 (Fairness category: C50 vs C40 vs C25 vs C20) mixed factor ANOVA as described above for the UG was carried out for trials on which participants provided the correct response. There was no main effect of Group, $F(1,58) = 3.25$, $p = 0.076$, $\eta^2 = 0.05$, but a significant main effect of Time, $F(1,58) = 97.35$, $p < 0.001$, $\eta^2 = 0.62$, again confirming that participants responded faster under time pressure ($M = 1280.16$, $SD = 300.42$) than under no time pressure ($M = 4773.21$, $SD = 3616.55$). In addition, there was a main effect of Fairness category, $F(3,174) = 13.29$, $p < 0.001$, $\eta^2 = 0.18$. Bonferroni pairwise comparison showed no significant differences in reaction time between C50 and C20,

C40 and C25 and between C20 and C40. However, participants were faster in C50 ($M = 2225.89$, $SD = 1523.03$) compared to C25 ($M = 3588.52$ $SD = 1999.82$; $p < 0.001$) and C40 ($M = 3468.91$ $SD = 2411.17$; $p < 0.001$) and they were faster in C20 ($M = 2823.44$ $SD = 1899.93$; $p < 0.001$) compared to category C25, which is the expected pattern considering that the C25 condition is the more difficult of the four conditions.

Table 4.6 Reaction time for the mathematical calculations for ASDs and TDs as a function of Fairness Category and Time condition

Timed	ASD		TD		Both groups	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
C50	1151.26	233.49	1150.62	358.98	1150.94	300.23
C40	1300.41	249.40	1391.22	461.54	1345.81	370.64
C25	1288.82	238.95	1390.10	275.46	1339.46	260.71
C20	1239.84	253.06	1329.07	283.36	1284.46	270.13
Overall	1245.08	243.72	1315.25	344.84	1280.17	300.43
Untimed						
C50	2893.57	1742.49	3708.12	3458.30	3300.84	1428.36
C40	5169.04	4095.38	6014.97	4814.19	5592.01	2745.84
C25	4913.13	2450.29	6762.04	4546.37	5837.59	4451.70
C20	3523.07	2096.11	5201.77	4415.48	4362.42	3738.95
Overall	4124.70	2596.07	5421.73	4308.59	4773.22	3529.74

In addition to the main effects, the analysis also yielded a significant Time x Fairness category interaction, $F(3,174) = 10.56$, $p < .001$ $\eta^2 = .15$. As Figure 4.5 suggests, the interaction was due to much more pronounced response time differences across conditions in the untimed compared to the time condition, which is not surprising.

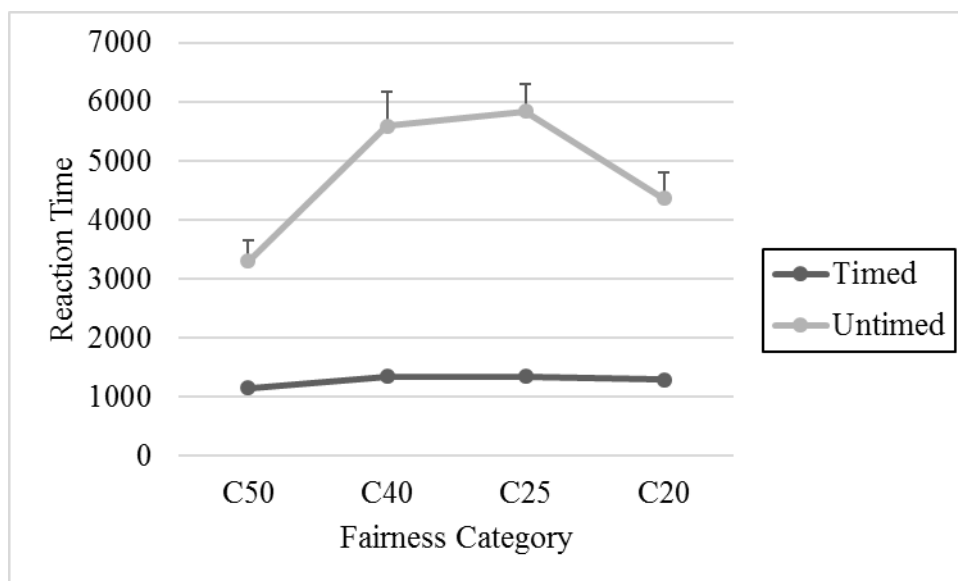


Figure 4.5 Mean Reaction time for responding to the mathematical task and Fairness category. * Error bars in the Timed condition are smaller than the width of the data-point markers on that line

All in all, the response time data from the mathematical decision task yielded the expected findings that participants generally respond quicker under time-pressure than under no time-pressure and that they generally take longer to respond to the more difficult C25 and C40 conditions than the easier C20 and C50 conditions. More interesting is a comparison of the response data set out in Figure's 4.4 and 4.5, which suggests that it takes participants considerably longer to give accurate responses to the mathematical questions than to decide whether to accept or reject offers, which may indicate that deliberate calculations of the kind participants were asked to perform here, are unlikely to play a significant role in deriving UG decisions.

4.3 Correlations / Predictors of Decisions

Cognitive Reflection Task, Theory of Mind, E-S, BIS/BAS, EPQ

Initial inspection of the data revealed no outliers for either the CRT or the Reading the mind in the eyes task and the histograms, normal Q- Q plots and box plots suggested that the measures were normally distributed. However, of the total sample five participants did not completed the ToM test (Two from the ASD group). Table 4.7 shows, for each group (ASD and TD), the mean accuracy score and reaction time for the cognitive reflection task (CRT) as well as the mean score for the theory of mind (RMIE), the E-S difference, BIS/BAS scale and the Ethics position questionnaire. Among all participants 12% of the total sample correctly responded to all answers, whereas 25% of the sample failed to respond to at least one problem correctly. The two groups performed similarly on the CRT task and comparison of the proportion of intuitive answers, wrong answers or CRT-Reaction time (CRT-RT), between the groups showed not significant statistical differences.

Comparison of the RMIE scores between ASD and TD groups showed a significant difference in this theory of mind measure. In accordance with the wider literature TD participants scored significantly higher than ASD participants on this task. There was also a significance difference in the E-S and BIS measures so that means for the ASD group showed a larger difference between empathizing and systemizing (E-S) and higher BIS compared to controls.

Table 4.7 Mean scores for ASDs and TDs in CRT, CRT-RT, RMIE, E-S, BIS/BAS, EPQ

	ASD (24m,6f)		TD (17m,13f)				
Measure	M (<i>SD</i>)		M(<i>SD</i>)		<i>t</i> (58)	<i>P</i>	Cohen's <i>d</i>
^a CRT_A	0.36	0.38	0.36	0.32	0	1	0
^b CRT_Int	0.38	0.31	0.4	0.31	0.35	0.72	0.06
^c CRT_Wr	0.27	0.25	0.23	0.24	0.6	0.55	0.16
^d CRT_RT	46447.26	26728.74	49835.42	22045.29	0.53	0.59	0.13
^e RMIE	0.67	0.13	0.74	0.08	2.5	0.01	0.67
^f E-S	-13.25	21.25	18.37	20.31	5.27	<.001	0.24
^g BIS	11.54	3.9	15.29	4.27	3.15	<.001	0.91
^h BAS	28.9	7.27	27.16	6.13	0.9	0.37	0.25
ⁱ EPQ _R	53.73	16.6	46.76	10.76	1.6	0.11	0.49
^j EPQ _I	63.61	17.86	66.47	13.9	0.57	0.56	0.17

^aCognitive reflection task, accuracy; ^bCognitive reflection task, intuitive; ^cCognitive reflection task, wrong answer; ^dCognitive reflection task, reaction time; ^eRMIE: Reading the mind in the eyes, ToM task; ^f Difference between Empathising-Systematizing; ^gBehavioural Inhibition BIS/BAS Scale; ^hBehavioural Activation BIS/BAS Scale; ⁱRelativism scale of the ethics position questionnaire; ^jIdealism scale of the ethics position questionnaire.

Correlations between overall UG-rejection rates (i.e., the average rejection rates across all fairness levels and across timed and untimed conditions) and the independent variables are shown in Table 4.8. Values highlighted indicate the correlation is significant. The results showed that UG-rejection rates were associated with higher CRT accuracy as well as higher ToM abilities and increasing VIQ scores when both groups data is combined. In other words, reflective thinking styles, greater theory of mind abilities and high VIQ were associated with greater acceptance rates across all conditions. Interestingly, these correlations were distinct for fair vs. unfair trials across conditions (Timed vs Untimed) Specifically, whereas ToM abilities and VIQ correlated with decision behaviour across all fairness categories, CRT only correlated with decision behaviour for unfair trials with more robust correlation under time pressure.

In a second step the same analysis was done for each group separately, rejection rate in the TD group was uncorrelated with ToM, VIQ, in all conditions; and for this group the CRT measure correlated only with rejection of unfair trials under time pressure. Interestingly, in the

ASD group ToM and VIQ significantly correlated with rejection behaviour of fair and unfair offers, under time pressure and not time pressure conditions, all $r > 0.30$. In addition, CRT correlated with rejection of unfair offers in the time pressure and no time pressure conditions.

Table 4.8 Correlations for CRT-RT, RMIE, E-S, BIS/BAS, EPQ and rejection behaviour by fairness and time manipulation

	C50 & C40)						(C20 & C25)					
	Timed			Untimed			Timed			Untimed		
	ASD	TD	Combined	ASD	TD	Combined	ASD	TD	Combined	ASD	TD	Combined
Age	0.02	-0.23	-0.12	0.18	-0.27	-0.05	0.07	0.32	0.19	0.04	0.3	0.17
VIQ	-0.53***	-0.36	-0.45***	-0.5***	-0.1	-0.36***	-0.43*	-0.24	-0.36***	-0.44*	-0.03	-0.29*
AQ	0.09	0.06	0.05	0.15	0.07	0.15	0.11	0	0.03	0.12	0.02	0.01
CRT	-0.19	-0.03	-0.11	-0.16	0.08	-0.06	-0.44*	-0.47**	-0.45***	-0.48**	-0.33	-0.42***
CRT-RT	0.18	0.21	0.19	0.17	0.25	0.2	0	-0.14	-0.03	-0.07	-0.26	-0.14
RMIE	-0.51**	0.09	-0.29*	-0.43**	-0.05	-0.35**	-0.54***	-0.12	-0.37**	-0.41*	-0.08	-0.27*
E-S	0.28	-0.01	0	0.16	0.1	-0.01	-0.03	0.06	0	-0.06	-0.04	0.01
BIS	-0.2	0.45	-0.01	-0.2	0.14	-0.14	-0.07	0.18	0.02	-0.02	0.22	0.08
BAS	-0.03	0.31	0.11	0.05	0.33	0.15	0.12	0.31	0.2	0.1	0.03	0.07
EPQ_ideal	0.27	0.17	0.22	0.22	0.03	0.15	0.29	-0.08	0.15	0.24	-0.05	0.13
EPQ_real	0.34	-0.21	0.25	0.25	-0.05	0.23	0.13	-0.3	0.03	0.06	-0.17	0

*** $p < 0.001$; ** $p < 0.010$; * $p < 0.050$

Given the observed correlations, two separate regression analyses were carried out to establish to what extent these factors contributed independently to decision behaviour in the timed and untimed conditions, using CRT and RMIE, the ToM measure, as predictors. It is worth noting that significant correlations were found between RMIE and the VIQ scores for both groups combined (all $r > 0.30$, $p < 0.050$). Further analysis, by group (ASD and TD separately) showed that these factors significantly correlate in the ASD (all $r > 0.40$, $p < 0.050$) but not in TD group (all $p > 0.050$) therefore in the regression analysis VIQ factors were excluded.

In the first analyses we regressed CRT and ToM scores on rejection rates for unfair offers (the average across C20 and C25 conditions) under time pressure. This regression yielded an overall significant model (Adjusted $R^2 = .229$; $F = 9.032$; $p = < 0.001$) in which CRT

($\beta = -.34$, $t = -2.90$, $p = 0.005$) and ToM ($\beta = -.87$, $t = -2.46$, $p = 0.017$) significantly and independently predicted reduced UG rejection rates. The second regression for the untimed condition also yielded an overall significant model (Adjusted $R^2 = .19$; $F = 6.437$; $p = .003$) but here only CRT ($\beta = -.36$, $t = -2.85$, $p = 0.006$) but not ToM ($\beta = -.19$, $t = -1.56$, $p = 0.12$) significantly predicted reduced UG rejection rates.

4.4 Discussion

The results presented in Chapters 2 and 3 of this thesis indicated contrary to predictions, that autistic individuals make very similar decision on the UG than typical individuals. Considering the cognitive characteristics of ASD and some limited literature on social-decision making in this disorder, these findings were somewhat surprising as several arguments lead to the prediction that autistic individuals should perhaps behave more according to rational economic principles than typically developing participants. The earlier experiments, however, did not consider the possibility that autistic individuals might arrive at the same decisions through more controlled and deliberative thought processes than comparison participants who may base their decisions more commonly on relatively automatic and instinctual processes that may be driven by emotion. Experiment 2 began to address this possibility to some extent by measuring emotion related somatic markers, but that study failed to replicate earlier findings by van t'Wout et al (2006) and it was therefore not possible to draw firm conclusions about the role of emotion-related processes in guiding decision behaviour. The study presented in the current chapter sought to further explore this issue by implementing a time-pressure manipulation that aimed to reveal the role of more intuitive vs. more deliberative reasoning processes in UG decisions by limiting the extent to which deliberative processes could be engaged (at least under one condition – time-pressure). To the best of our knowledge this is the first study to use a time-pressure manipulation as way to explore and compare the cognitive processing underlying social decision making in ASD and TD individuals.

Before discussing the main results on the UG task, it is important to highlight briefly that the time-pressure manipulation employed in this study was generally effective. First, results of a mathematical control task, confirmed a significant effect of the time-pressure manipulation on participant's accuracy in judging whether a certain amount of money offered was more or less than 30% of a given pot. Second, in the main UG task, response times under the untimed condition were on average longer than the response time limit implemented under the time-pressure condition, suggesting that this condition did restrict the amount of information processing that participants might otherwise engage in. The fact that the time-pressure manipulation generally had the desired effect of hampering deliberate reasoning is important because, as noted in the introduction, it remains still unclear whether or not quick and automatic processes that are relatively free of deliberation would generally lead to rejections or acceptances of unfair offers. One line of evidence suggests that participants would naturally be inclined to reject unfair decisions based on a fairly automatic emotional aversion to inequity or unfairness, which motivates decisions that seek to punish undesirable social behaviour (i.e., unfairness) for the greater good of social norms (Pillutla & Murnighan, 1996; Sanfey et al., 2003; van 't Wout et al., 2006; Stutter et al., 2003). By contrast, other evidence has suggested that acceptance might be the default decision due to self-serving biases that aim to maximise self-benefits (e.g., Knoch et al., 2006).

The current study tends to support the first of the above possibilities. Specifically, across both ASD and TD participants, increased rejection rates were observed for fair and particularly marginally unfair (C40) offers with little effect on rejection rates of very unfair offers that would typically be rejected under most conditions. The increased rejection rate of marginally unfair offers is particularly interesting considering that such offers are likely to cause the most cognitive conflict between the potential personal benefits of accepting vs. the wider societal detriments of encouraging unfair behaviour. It is worth remembering that in

Chapter 3, marginally unfair offers were also the most sensitive to the manipulation of computer vs. human proposers. The increased rejection rates of this offer in the current study suggests that under conditions that limit the engagement of deliberative reasoning, participants are inclined to default to rejection, most likely because of the aversive feelings or connotations that are associated with unfairness or inequity. Formulated in relation to acceptances, the findings therefore also suggest that acceptance of unfair offers is likely to result from more deliberative and controlled reasoning. Analysis of decision behaviour without controlling for mathematical performance suggests higher rejection for fair and marginally unfair offers under time pressure compare to no time pressure. However, when controlling for performance in the mathematical task, rejection rate is unaffected by time pressure. This suggest that people's mathematical skills influence the extent to which their decision behaviour is affected by time pressure.

Furthermore, the association between acceptance of unfair offers and controlled reasoning showed that increased performance on the 7i-CRT, which is indicative of more reflective reasoning styles, was associated with decreased rejection/increased acceptances across all offers. Our result in this respect are in accordance previous results reported by Oechssler, Roider, & Schmitz (2008) who found that higher UG rejection was associated with poor performance in the 3-items CRT. Similarly Calvillo & Burgeno, (2015) and De Neys et al., (2011) also found an association between the extended version of the CRT used in the current study and UG decision behaviour, whereby a higher tendency to be reflective was associated with greater acceptance rates. Interesting in relation to these correlations is that the current study furthermore indicated that ToM ability as measured through the RMIE was also associated with reduced rejection rates, which may indicate that mentalizing plays a role in the deliberations that lead participants to accept.

Although the results of the current study are generally in line with one of the few (if not the only) studies to examine the effect of time-pressure on UG decision behaviour by Sutter, Kocher & Strauß (2003), it is worth noting some differences in findings and the paradigms used. Specifically, similar to the conclusions drawn here, the authors reported that rejection appears to be the default automatic response in the first of 9 rounds of a €10-UG. Unlike in the current study, however, a bias to reject was not observed across the entire experiment; from the 2nd trial onwards in that study the time pressure effect vanished, and acceptance became the default response.²²

Two factors are likely responsible for the difference in findings between the current study and Sutter et al.,(2003). First, in relation to offers and payments, in the current design participants played under both treatments (Time pressure vs Not time pressure), and although participants received offers from different pot sizes, the incentive was kept constant throughout the 48 trials (10 % of each accepted offers). Instead, Sutter et al., (2003) assigned participants to one of two conditions (Time pressure vs Not time pressure), used a fixed (€10) pot and made participants aware of the number of trials. From the second trial onwards, once the repetition became apparent, there would therefore be a reduction in the need for any cognitive deliberation (i.e., it counteracted the time-pressure manipulation) given that there are no new processing demands on successive trials. Second, the current study implemented a much shorter time window during the time-pressure condition (2 secs), than Sutter et al., (2003; 10 sec), which may further limit the effectiveness of the manipulation across multiple trials.

Issues related to the response time limits during the current time-pressure condition, may also help explain why the current findings differ from the evidence reported by Knoch et

²² It is worth noting that it was not possible in the current experiment to analyse responses only from the first trial for comparison because the order of trials (i.e., of different pot sizes and fairness levels) was randomised and therefore each participant would have received different offers on the first trial.

al., (2006) who showed that transcranial magnetic stimulation (TMS) that disrupts deliberative processes, decreases rejection of unfair offers, suggesting that acceptance is the automatic and intuitive response. However, the response time data reported by Knoch et al., (2006) indicated that participants took on average around 4 seconds to provide their responses even under the conditions in which Knoch et al., (2006) argue primarily automatic processes are engaged. The current study suggests that participants engage in deliberative processes already by around 3 seconds [RTs (Timed: $M = 1170$, $SD = 0.287$); (Untimed: $M = 2882$, $SD = 1825$)], and therefore the TMS stimulation in Knoch et al., (2006) may not have disrupted all of the deliberative process that may be involved in acceptances. In particular, it may be the case that participants in the Knoch et al., (2006) study were encouraged to engage ToM processes that the current study implicates as a contributor to acceptances. This is likely, because the design employed by Knoch et al (2006) involved a proposer manipulation similar to that described in the previous chapter (i.e., human vs. computer proposers). The uncertainty about whose offer was coming next, may have boosted theory of mind and acceptances, which would be in line with the results of the previous experiment where acceptances of computer offers were higher than those of human proposers.

Turning now to the comparison between decision behaviour in ASD vs. TD participants, the results of the current study concur with those of the previous two in suggesting that there are few if any differences in how autistic and non-autistic participants reach decisions in UG scenarios. Rejection and acceptance rates of the different offer categories were indistinguishable between the groups and both groups responded very similarly to the time pressure manipulation. Some subtle differences emerged in the pattern of correlations between CRT, ToM and rejection rates across fair and unfair offers. Specifically, for ASD participants, ToM and CRT correlates with rejection rates in the same way across all experimental conditions whereas for TD participants the pattern differs somewhat for timed vs. untimed

conditions. These different patterns across both groups might indicate that TD participants adapt more flexibly to the demands of the timed and untimed conditions than ASD participants. Specifically, whilst TD participants engage cognitive reflection and ToM differentially depending on the circumstances, ASD participants may deploy these processes irrespective of the situational demands. This difference, therefore, could reflect an aspect of the executive function difficulties that are commonly associated with ASD (particularly in the domain of cognitive flexibility).

It is important to note that the results in the current study did not demonstrate differences between TD and ASD groups on the 7i-CRT scores unlike the results by Brosnan, et al., (2014) and De Martino et al., (2008), who suggest that ASD individuals reason more logically and reflectively, and are thus less inclined to follow heuristics. Possible reasons for the discrepancy include sample characteristics such as clinical characteristics or participant age. If differences in sample characteristics are among the reasons for the discrepant findings in relation to the CRT, this raises the possibility that the current sample of adults participants is more heterogenous than the group of students in Brosnan, et al, hence it is possible to suggest that the findings apply only to a subset of individuals in the spectrum or that our sample is not representative of the wider autism spectrum. I will return to this possibility in more detail in the final discussion chapter.

However, the results may not be associated with the sample itself but with the characteristics of the measure. For instance, it is known that some forms of intuition are associated with highly overlearned tasks, however it does not mean that the person has or not an intuitive cognitive style (Lieberman., 2000; Kahneman & Klein., 2009). Performance in the CRT interacts with knowledge, available heuristics, environmental characteristics and open-minded thinking (Campitelli & Labollita., 2010) and has been found to positively correlate with measures of utilitarian moral judgement, scientific understanding & creativity, reasoning

and decision-making tasks, see (Pennycook et al., 2016). In fact, the current study extends this evidence. A positive correlation between CRT performance and UG responder, i.e. acceptances was observed, which indicates that different systems are involved in acceptances vs rejection behaviour therefore the UG is also a good test for testing dual theories.

Interestingly, it could be that the incentive of a £0.30 payment for correct responses in the current study somehow changed the nature of the task so that it was no longer sensitive to group differences. This seems unlikely, however, given that the levels of accurate vs. intuitive and inaccurate answers seem ideally distributed to detect group differences.

For now, it is important to note that one of the implications of this possibility would be that a more representative sample of autistic individuals, might be more likely to accept unfair offers in the UG given that the increased tendency for reflection in such a group would be expected to lead to higher acceptances as indicated by the correlations observed in the current study and previous studies mentioned earlier.

Unlike the results for the CRT, data from the RMIE task did replicate earlier findings in showing that autistic individuals experience difficulties in ToM. Despite the fact that ToM was correlated with increased rejection rates, however, the group differences in ToM were not associated with accompanying decreased acceptance rates of unfair offers. Our regression model suggests that the RMIE, our ToM measure, significantly predict acceptances in the UG. Interestingly though, ToM abilities do not predict decision behaviour in cases of extreme unfairness and when there is no time pressure. Only in such a case the CRT is significant in the model, suggesting that the certainty of a social rule, such as equating fairness to egalitarian splits, prevail over perspective taking considerations. Thus, the lack of group differences between ASD and TD participants, despite differences in ToM, might be the consequence of

the fact that multiple factors interact in guiding decision behaviours and the specific role of ToM may not be easy to isolate.

In summary, the study presented in this chapter once again suggested that autistic individuals behave very similarly in the UG scenario as compared to typically developing participants. Unlike in the previous chapter, where a manipulation of the proposer (human vs. computer) appeared to affect decision behaviour differentially in ASD and TD participants, the time pressure manipulation in the current study had fairly similar effects on both groups. Although correlations between ToM ability, reflective thinking and UG decisions in the current study were also broadly similar between groups in the current study, subtle differences in the patterning of these correlations across experimental conditions suggests that autistic individuals might engage ToM less flexibly to different situational demands. In order to examine this issue further, the last experiment examined decision behaviour in a variant of the UG – the so-called Mini UG – that offers some experimental control over the role of mentalising by contrasting decisions to unfair offers that proposers have either made intentionally or not.

5 EXPERIMENT FOUR: MiniUG

In the four studies using the ultimatum game presented in the previous chapters, participants responded to unfair and fair offers made by others without knowing the underlying motivations and the circumstances in which these offers were made. Did the proposer intentionally offer an unfair amount or maybe accidentally? Could they have been under some financial strain that motivated their unfair offer? Or maybe they were encouraged to offer an unfair amount by someone else? Any number of speculations like these might inform people's decisions on whether to accept or reject an unfair offer but it is equally possible that their decisions are simply guided by the inequity of the proposed amounts and/or by the absolute amount of money on offer. This last experiment sought to discriminate between outcome unfairness and intentional unfairness, by using options that are unfair but are the fairest available to the proposer and making this information available to the responder.

This variant of the ultimatum game, known as the mini-ultimatum game (hereafter MiniUG; Falk et al., 2003) can reveal the extent to which participants either engage an outcome based decision approach that is relatively insensitive to the options available to the proposer (Bolton & Ockenfels, 2000; Fehr & Schmidt, 1999; Loewenstein, Thompson, & Bazerman, 1989) or instead an approach that takes into consideration the motivations and intentions of the proposer given the contextual constraints under which they are formulating unfair offers (Charness & Rabin, 2002; Dufwenberg & Kirchsteiger, 2004; Levine, 1998; Rabin, 1993), thus involving a certain degree of theory of mind reasoning.

The MiniUG is made up of four ultimatum game scenarios with the same pot size but different payoffs. Whereas, in the standard Ultimatum the proposer has no restrictions on how to split the pot (Total Pot -X), in the MiniUG, the proposer is given two options of how to split the money, an unfair option that is constant across four games labelled here the fixed-split (e.g.

£8 ; £2), and an alternative-split that is either fair (£5; £5) or even less fair than the constant (£9 ; £1). Thus, across all four games responder behaviour can be compared to offers with a fixed absolute ‘unfairness’, but a variable relative unfairness given the constraints imposed on the proposer. To illustrate, Table 5.1. shows the structure of the MiniUG with a £10 pot, as used by Falk, Fehr, & Fischbacher (2003) along with the decision behaviour of proposers and responders. The fixed-split (8:2) is presented with a different alternative-split each time, either with (5:5); or (8:2); or (2:8); or (10:0) and it is clearly evident that responders are sensitive to this manipulation, rejecting the unfair offer significantly less often when the proposer has no fairer alternative to choose.

Table 5.1 MiniUG Full trial and results patterns as in Falk et al., (2003)

	Fixed-split		Alternative-split		% of times Offered	% of times Rejected
	For me	For you	For me	For you		
Game 5			£5	£5	31	44.4
Game 2	£8	£2	£8	£2	NA*	18.0
Game 8			£2	£8	74	26.7
Game 0			£10	£0	100	8.9

*Game 2 is not calculated in proposer behaviour as both options available to the proposer are the same.

The pattern of decision behaviour observed by Falk et al., (2003) has been replicated consistently, reliably showing that individuals are overall less likely to reject unfair offers when they see that the proposer has no fairer option available to them (Falk et al., 2003; Güroğlu et al., 2009; 2010; Pelligra et al., 2015; Sutter, 2007). However, there is also evidence showing that rejections are observed when the fixed-split is presented with an alternative distribution which is exactly the same i.e. Game 2 in Table 5.1, suggesting that fairness perceptions guide individuals’ decisions in the MiniUG differently. Further support for this conclusion stems from studies that examine decision behaviour from a developmental perspective. Specifically, whereas adults’ appreciation of fairness is modulated by contextual factors, for instance by

making distinction between intentional or accidental behaviours (Blount, 1995; Castelli et al., 2014; Van't Wout et al., 2006) children under 5 years of age, hold a concept of fairness which is closely associated with the fairness of the outcome (Wittig, Jensen, & Tomasello, 2013). In the context of the Mini UG, for example, developmental effects in fairness perceptions have been looked at by comparing decision behaviour in different age groups (Sutter, 2007), 5-year olds children (Wittig et al., 2013), university students (Brandts, 2001) and adolescents at different stages of age in both roles as proposers and responders (Güroğlu, van den Bos, & Crone, 2009). Together the evidence suggests differentiated fairness sensitivity that varies with age, where younger participants were relatively more often driven by outcome-fairness than older participants. Hence assigning importance to intentions over outcomes in fairness judgments seems to increase gradually with age.

Considering the processes that guide decision behaviour in the MiniUG, studies point to a critical role of mentalizing in the moderation of rejection rates based on the manipulation of the alternative offers. For instance, in a study by Güroğlu et al., (2010) 25 university students (15 females) were invited to play a MiniUG in the role of responders while undergoing functional brain imaging. Participants received 192 offers, of which 24 served as practice trials and 42 trials on which participants received fair and hyper-fair offers instead of the unfair fixed-split. Decision time was set up to 5000 ms, which, based on the results of the study described in the previous chapter, should be sufficient for participants to engage ToM related processes in a deliberative fashion. The behavioural results of this study showed the expected pattern of results, with significantly fewer rejections of the fixed offer when the alternative offer was even less favourable to the responder. More importantly, activation in the insula, a brain area associated with social norms violations (Spitzer et al., 2007) or inconsistency response with expectations, was observed during rejection of the fixed-split in game 20% when the proposer had not alternative, acceptance of the fixed-split in game 50% and game 80 % where the

alterantive split was fair and hyperfair, respectively. This was used as evidence to demonstrate that the intentionality of the offers, i.e the four games, is associatd with moral judgement and decision behaviour.

In a different way, the respective importance of mentalizing vs. outcome oriented decision processes were examined by Güney and Newell (2013) in a two-parts study. In the first part, a group of university students were asked to play a series of mini-ultimatum games as responders under conditions where offers were said to be coming from either computers or humans, even though the offers were set up by the experimenters to follow the offer distribution of Falk et al., (2003). Testing took place in groups of five students and each participant was told that only one participant in each group would be assigned to the role of responder, thus leading participants to believe that a real and different proposer made the different offers across the human trials. Participants played for real money and were informed about the overall outcomes after responding to all of the four possible game scenarios. Participants demonstrated the expected pattern of response behaviour in this part of the experiment.

However, in the second part results were slightly different. In this part the experimental designed was modified to test whether reputation building, and the foreseeing of future interactions would have an impact on MiniUG decision behaviour and an alternative explanation to the involvement of theory of mind abilities in these decisions. To achieve this anonymity was removed from the interaction and participants were asked to play face to face with a different partner in each game. Rejection increased in overall, however, compared to the results in Part-1, the rejection rate was higher for the (8:2) game when both options available to the proposers were equally unfair. Results were used as evidence to suggest that other factors such as reputation building, and the foreseeing of future interactions play a role in decision behaviour only for interactions lacking intentionality clues.

Given the evidence just outlined, and the results of the previous experiments, which suggest that autistic individuals may rely on ToM abilities to guide their decision behaviour in the UG, but not adapt their metalizing flexibly to the specific context of the UG scenario, we might expect that rejection rates across the four scenarios of a MiniUG might vary less in ASD than TD participants. To our knowledge only one study to date has used the MiniUG to examine decision behaviours in the context of ASD. Pelligra et al., (2015) invited 20 autistic children and 60 TD children, all male and matched on IQ, to play the MiniUG over four trials using the strategy method²³. ASD children played only as responders and so did 20 of the TD participants, with the remaining 40 TD participants playing only as proposers. Children played for Pokémon' cards and were asked to choose between them before starting the MiniUG to ensure they had high motivational value. In addition, and before playing the MiniUG, second order ToM abilities were also assessed using the Ice cream test (Perner & Wimmer, 1985; see Chapter 1 for details). Proposer's decisions by the 40 TD showed that they chose the fixed split more often (100%) when the alternative option was (10:0) but it was only chosen 30% of the times when the alternative offers was (5:5). More importantly turning to the responder behaviour, TD children in 75% of the cases, rejected the fixed split when the alternative was (5:5) whereas in the (10:0) game the fixed split was only rejected in 5% of the cases, clearly demonstrating the expected sensitivity to the proposer's options. The ASD group, however, was far less sensitive to the manipulation rejecting the fixed split 60% of the time when the alternative was the fair offer, but also 45% of the time when the alternative was even more unfair. Moreover, when examining decision behaviour as a function of whether children had passed the ToM test, the authors found that this had an effect only in the TD but not the ASD group. Specifically, TD children who passed the ToM test were more sensitive to the alternative

²³ In the Strategy method, participants are asked to respond to all the possible options available to the proposer, in total eight responses for the standard MiniUG.

offer manipulation than children who failed with no such difference being evident in the ASD group. The authors concluded, on this basis, that whilst ToM seems to play an important role in informing the decisions that TD children made on the MiniUG, other factors seem to play a role for ASD children, although it is also possible that ASD children did engage ToM as well but simply did not adapt how they did so to the different scenarios, i.e., ASD children may have thought about the possible motives of the proposer without adjusting their reasoning depending on the alternative options they had available.

Given this pattern of results observed by Pelligra et al., (2015), together with the results reported in the previous chapters and the wider literature concerning ASD, this final experiment tested the prediction that decision behaviour in autistic adults would be less sensitive to the MiniUG manipulation than comparison participants but that rejection rates might nevertheless be correlated with ToM abilities as in the previous chapter, where greater ToM was associated with overall lower rejection rates of unfair offers.

5.1 Method

Participants

Fifty-five adults, twenty-seven with autism and 28 individuals without a diagnosis of ASD were involved in this experiment. Participants were recruited from an existing database to include autistic and typically developing adults. They were paid standard University fees of £8/hour for their participation plus the earnings from two randomly selected trials of the mini-UG (see below for details). ASD participants provided documentation to confirm that they had been diagnosed by suitably qualified clinicians through the National Health Service according to DSM-IV-TR criteria and additional assessment with the Autism Diagnostic Observation schedule, ADOS (Lord et al., 2012) further corroborated impairments in reciprocal social and communication behaviours that are the defining feature of the disorder. Twenty-one participants met the relevant cut-off criteria for ADOS. Although the remaining twelve scored

below the threshold, they were retained in all analyses since the records they provided confirmed their clinical diagnosis and it is well known that the ADOS module 4 is susceptible to false negatives. Typical individuals were selected to match ASD participants on Full-Scale IQ as measured by the Wechsler Adult Intelligence Scale III or IV (Wechsler, 2000, 2008) and chronological age. All participants also completed the Autism Spectrum Questionnaire (Baron-Cohen, et al., 2001) which provided further corroboration of the diagnosis in ASD participants and confirmed that none of the TD participants reported above-threshold autism-related traits. None of the participants in either group reported a family history of neurodevelopmental or psychiatric illness, drug or alcohol abuse which would have led to exclusion. Table 5.2 summarises the characteristics of both groups.

Table 5.2 Characteristics for autistic individuals (ASD) and Typically Development Individuals (TD)

Measure	ASD (21m,6f)		TD (19m,9f)		<i>t</i> (53)	<i>P</i>	Cohen's <i>d</i>
	<i>M</i> (<i>SD</i>)		<i>M</i> (<i>SD</i>)				
Age (years)	50.44	11.88	56.36	13.48	1.72	0.91	0.46
^a VIQ	108.04	27.44	108.5	22.24	0.67	0.94	0
^b PIQ	102.5	18.32	110.31	14.72	1.69	0.96	0.46
^c FIQ	109.35	19.55	112.44	14.28	0.64	0.52	0.21
^d AQ	33.41	7	13.46	4.99	11.9	< 0.001	2.28
^e ToM _{REMIE}	0.63	0.14	0.75	0.08	3.71	0.001	1.05
^f ADOS-C	3	1.77					
^g ADOS-RSI	5.73	2.81					
^h ADOS-Total	8.73	4.15					

^a Verbal IQ (WAIS-III^{UK} or WAIS IV^{UK}); ^b Performance IQ (WAIS-III^{UK} or WAIS IV^{UK}). ^c Full Scale IQ (WAIS-III^{UK} or WAIS IV^{UK}); ^d Autism Spectrum Questionnaire (Baron-Cohen et al.,2001); ^e Reading the Mind in the Eyes, ToM task; ^f ADOS- Communication; ^g ADOS- Reciprocal Social Interaction; ^h ADOS Total Score- Communication + Reciprocal Social Interaction

Materials & Design

As in Falk et al., (2003) the current study uses the pot's distribution presented in Table 5.1. However, in addition, six pots of money were used instead of one, and participants were asked to play both roles, as responders and proposers. The implementation of different pot sizes was made to increase the number of trials participants could be asked to respond to without relying on very simple response strategies or biases. To preserve the ecological validity of the study and to make the experiment affordable, participants were informed that the experimental program would randomly select one of the trials on which participants served as proposers, to serve as a 'real' offer for the next participant in the responder role (thus one of the responder trials was also 'real'). This trial was fully paid out according to the rules of the UG and this was all made clear to participants. Since the 'real' trial would be indistinguishable from all the other trials, participants were encouraged to treat all trials as real.

The current design had six MiniUG games, for the pot sizes (£10, £20, £30, £40, £50, £60). For each MiniUG, the standard four sets of trials were generated that required participants in the responder role to decide which of two options to pass on to responders; a fixed unfair split (80% vs. 20%) and an alternative split that varied in fairness (50%-50%; 80%-20% and 100%:0%), which will be described as the 50%, game 20%, game 80% and game 0% respectively. These values indicate the proportion of the pot going to the responder if the alternative split is chosen. Table 5.3. provides an overview of all trials included in the design for ease of reference.

Table 5.3 Splits by money pot in £s and percentage of the total amount offered in the alternative split by game

Pot £	Alternative-Split		Game	Fixed-Split	
	For Me £	For You £		For me 80% £	For you 20% £
10	5	5	(1) 50%	8	2
10	8	2	(2) 20%	8	2
10	2	8	(3) 80%	8	2
10	10	0	(4) 0%	8	2
20	10	10	(1) 50%	16	4
20	16	4	(2) 20%	16	4
20	4	16	(3) 80%	16	4
20	20	0	(4) 0%	16	4
30	15	15	(1) 50%	24	6
30	24	6	(2) 20%	24	6
30	6	24	(3) 80%	24	6
30	30	0	(4) 0%	24	6
40	20	20	(1) 50%	32	8
40	32	8	(2) 20%	32	8
40	8	32	(3) 80%	32	8
40	40	0	(4) 0%	32	8
50	25	25	(1) 50%	40	10
50	40	10	(2) 20%	40	10
50	10	40	(3) 80%	40	10
50	50	0	(4) 0%	40	10
60	30	30	(1) 50%	48	12
60	48	12	(2) 20%	48	12
60	12	48	(3) 80%	48	12
60	60	0	(4) 0%	48	12

In addition to the 24 experimental trials, when participants acted as responders, 6 control trials were also included for which participants would receive the fair rather than the fixed offer (i.e., £5:5; 10:10; 15:15; 20:20; 25:25; 30:30). Trials were presented in random order with the fixed 20%: 80% offer appearing on the left or right side of the screen on half of the trials. Participants completed three conditions of the experiment in a fixed order. First, they acted as responder and needed to decide whether to accept or reject offers from a proposer. Second, in what was called the Forecasting condition, they were asked how many of 100 people they think would be likely to accept or reject certain offers. And finally, they acted as proposer and choose between the two available splits, the one to be passed on to a responder. As in the previous experiments, the Reading the mind in eyes task (ToM_{RMIE}; Baron-Cohen et al., 2001) as a measure of ToM and administered at the end of the Mini UG conditions unless the data was already available.

Procedure

Participants were tested individually in the Autism Research Group laboratories of City, University of London. Participants received on paper a full description of the experiment and provided written consent. There were no practice trials, but reminders of the instructions were provided before each of the experimental conditions.

Participants completed the experimental tasks in one testing session. They first played as responders, then in the forecasting condition, participants predicted the decisions of others, and finally played the role of proposers. The number of trials was not disclosed to participants at any stage in the experiment. Between each condition, participants completed unrelated online tasks for a few minutes to provide breaks between the main experimental conditions and to reduce potential carry-over effects between them. The order of the three experimental conditions was kept constant across all participants whereas the order of the trials was

randomized for each participant and each condition. Time during each condition was measured but not limited and feedback was given only at the end of experiment. The experimenter was in the room only at the beginning of each task to set up the session.

In the role of responders, participants were informed that their task was to decide whether to accept or reject offers made by a number of proposers. Participants also learned that they were to make this decision on several trials, and that one of those trials presented an offer that a previous participant chose in their role as proposer, therefore their decision would affect whether that person would get paid. Immediately after, participants were presented with the task, with a brief reminder of the instructions at the start. Participants were required to input their response by key press, using “A” to accept and “R” to reject offers.

Each trial then started with a fixation cross on the screen for 500 milliseconds, followed by a screen with the two splits the proposer had available to choose from with the name of a proposer appearing centrally above the two alternatives in the form “These options were available to Thomas” The two choices remained on the screen for 2000 milliseconds, and then one of the choices was highlighted with a green frame to indicate it was the offer chosen by the proposer. At the bottom of the same screen a prompt appeared for the participant to give their response. Participants needed to decide whether to accept or reject the split highlighted in green, for which they had an unlimited time. After entering the response, a fixation cross stayed on the screen for 500 milliseconds before the next pair of offers appeared on the screen. The same procedure was repeated over thirty trials, of which six were control trials as noted above. For each pot, the responder decided over the Fixed-split. The Fixed - split was always 80%: 20% which was presented four times, each time along with one of the alternative splits that varied in fairness as explained above (Games 50%; 20%; 80%; 0%). The program was set to always highlight in green the Fixed, with the exception of the control trials where the fair split was highlighted. Figure 5.1 shows the sequence of events for a responder trial.

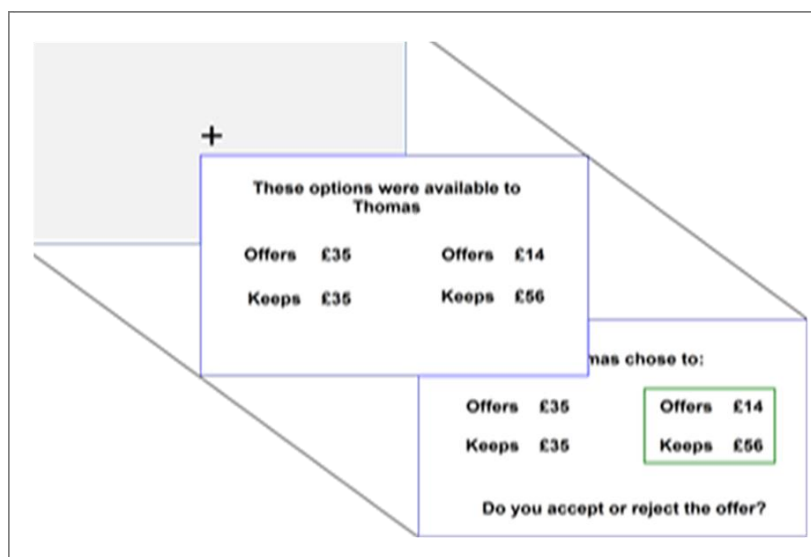


Figure 5.1 Sequence of events in a trial for a responder

After a ten-minute break, in the same room but using a different monitor, participants did one of the unrelated online tasks. Once that was finished, they were invited to do the second main condition (the Forecasting condition). Here participants were told that they would see offers again as in the previous task, but that this time they would need to indicate how many of 100 people they think are likely to accept the offer option that would be highlighted in green for them. During this task participants typed a number between zero and one hundred at the response screen stage to indicate the number of people they thought would accept the highlighted offer. Figure 5.2 shows the sequence of events for a trial in this condition. Importantly, to incentivise careful responding also on this task, participants were informed that their accuracy on this part of the experiment would be rewarded. Specifically, participants who came closest in their estimates to the actual response distribution in the responder part of the session, would receive a £5 payment.

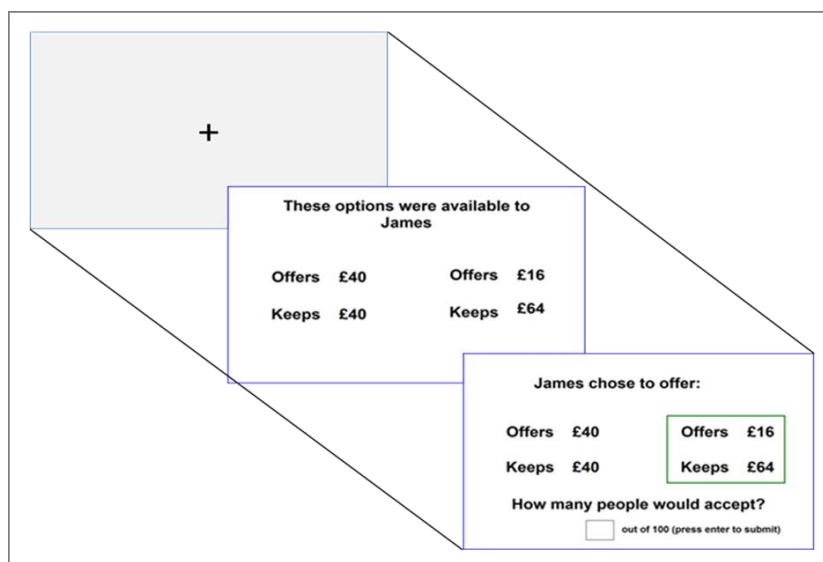


Figure 5.2 Sequence of events for the forecasting condition

Finally, following another short unrelated task, participants played the role of the proposer, this time deciding which of the different offer options they would like to pass on to other responders. Offers were again presented in a similar format to the previous parts of the session (see figure 5.3), but rather than having an option highlighted, participants needed to select an option by pressing the left or right arrow keys, which then highlighted that option for 200ms with a green frame before the next offer options appeared (a 500ms fixation cross) separated the trials). After all trials in this proposer part, the programme ended by displaying a randomly chosen trial that would be passed on to the next participant (customized script ensured that this was actually reflected in the pay-outs that would be implemented in the responder condition such that there was no deception involved).

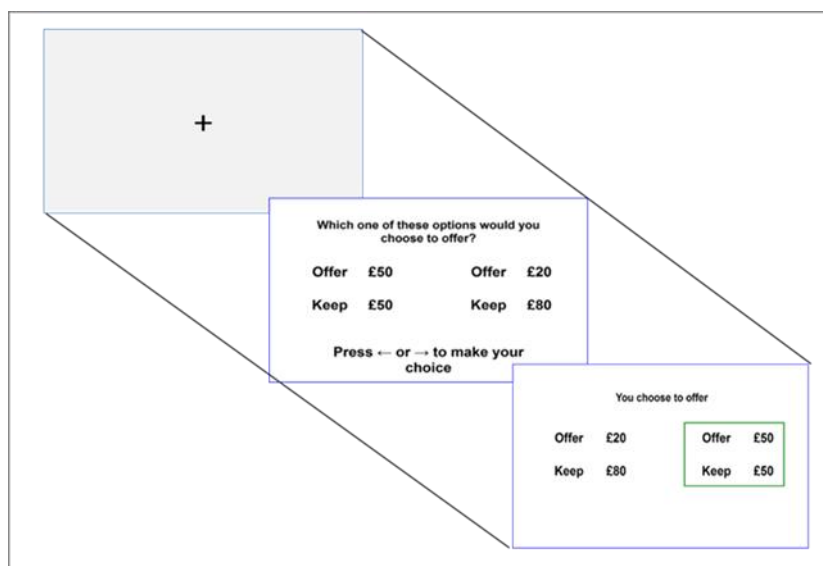


Figure 5.3 Sequence of events for a proposer trial

At the end of the session, participants completed the RMIE task if necessary, and were then paid for their time and for any additional payments that were due as a result of the UG decisions. The whole testing session lasted approximately an hour and half.

5.2 Results

Ultimatum Game

Results are presented separately for each condition (proposer and responder). Although participants played first as responder and then as proposer, we commit to what is customary in the field and report proposer behaviour first followed by responder. For each of these conditions the results showing the relation between decision behaviour and theory of mind abilities is presented immediately after the analysis of decision behaviours.

Proposer behaviour

For each individual, data was first averaged across pot sizes and then across participants to derive the average percentage of times that participants opted for the fixed split offer as proposers. Figure 5.4 sets out these data as a function of group and of the alternative offer

available. The condition in which both offers were of the fixed amount type were excluded from this analysis as these trials did not present any real option. These trials were included so that the Responder and Proposer conditions were equivalent in all respects.

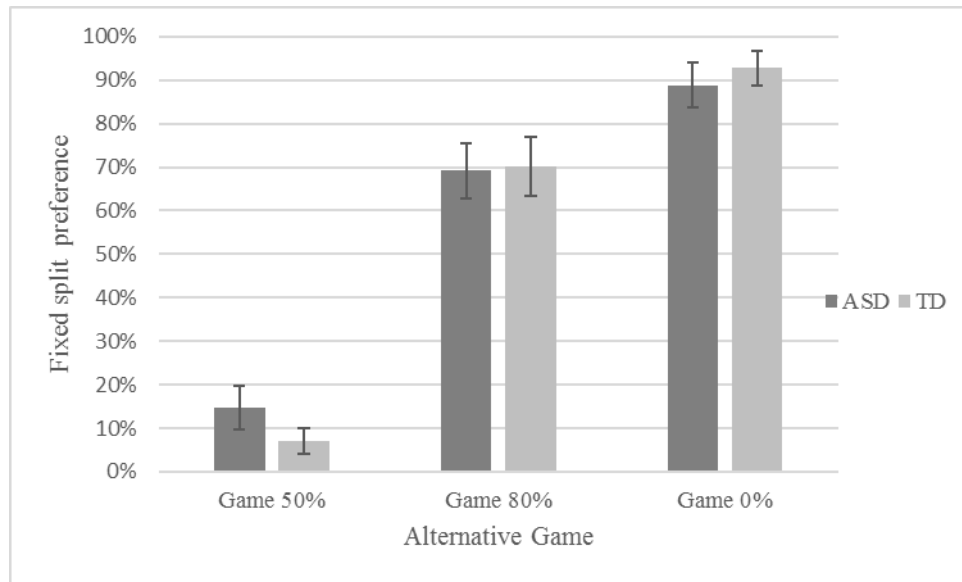


Figure 5.4 Percentage of times the (80:20) fixed split was chosen as offer instead of the alternative-split, by group

A 2 (Group: TDs vs ASDs) x3 (Fairness: game 50% vs. game 80% vs. game 0%) factorial ANOVA yielded a main effect of fairness, $F(2,106) = 113.58$, $p < 0.001$, $\eta^2 = 0.68$. Bonferroni corrected pairwise comparisons showed that participants were significantly more likely to offer the fixed-split (80%:20 %) in game 0% ($M = 0.91$, $SD = 0.24$) compared to game 80% ($M = 0.69$, $SD = 0.34$; $p = 0.001$) or game 50% ($M = 0.11$, $SD = 0.21$; $p = 0.001$). There was no main effect of Group $F(1,53) = .058$, $p = 0.81$, $\eta^2 = 0.001$, and no significant game X group interaction $F(2,106) = 0.606$, $p = 0.54$, $\eta^2 = 0.011$ suggesting very similar performance across both groups.

Responder behaviour

The average rejection rates of the fixed-split (80% : 20%) across games and groups is presented in Figure 5.5 Rejection rate follow the same patterns as reported by (Falk et al., 2003).

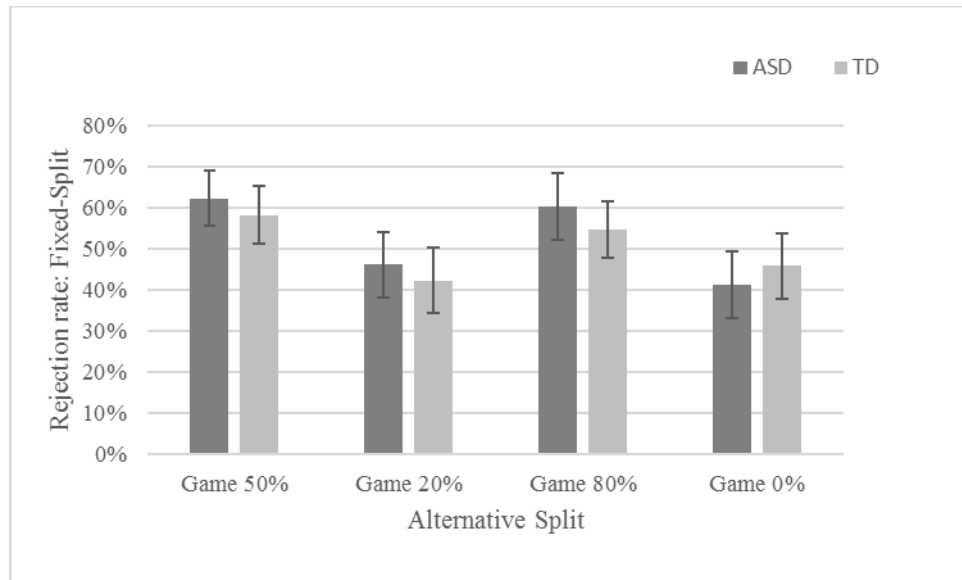


Figure 5.5 Rejection rate of the fixed-split across games and by group

A 2 (Group: TDs vs ASDs) x 4 (Fairness: Game 50% vs. Game 20% vs. Game 80% vs. Game 0%) mixed ANOVA yielded a main effect of Fairness $F(3,159) = 9.21, p < 0.001, \eta^2 = 0.148$. Bonferroni corrected pairwise comparisons showed that there was no significant difference in participants' rejection of the fixed split between Game 50% and Game 80%, and between Game 20% and Game 0% ($p = 1.000$). However, rejections between these pairs of conditions were significantly different with higher rejections in Game 50 ($M = 0.60, SD = 0.35$) and Game 80 ($M = 0.57, SD = .41$) compared to Game 20% ($M = 0.44, SD = .41$) and Game 0% ($M = 0.43, SD = 0.41$) – all $ps < 0.005$. There was no main effect of group $F(1,53) = 0.58, p < 0.81, \eta^2 = 0.001$ or significant fairness x group interaction $F(3,159) = 0.64, p < .58, \eta^2 =$

0.012, suggesting very similar patterns of responder behaviour in the two groups, unlike the results reported by Pelligra et al., (2011).

Response time data for the responder condition similarly revealed no evidence of group differences. The data are set out in Figure 5.6. and a 2 (Group: TDs vs. ASDs) x 4 (Fairness: game50% vs. game 20% vs. game 80% vs. game 0%) mixed ANOVA indicated no main effect of group $F(1,53) = 0.73, p = 0.78, \eta^2 = 0.001$ or interaction between fairness x group $F(3,159) = 0.092, p = 0.96, \eta^2 = 0.002$ although the main effect of fairness was again significant, suggesting that responses on conditions where the fixed split is typically rejected participants required somewhat more time to respond $F(3,159) = 2.89, p = 0.037, \eta^2 = .052$.

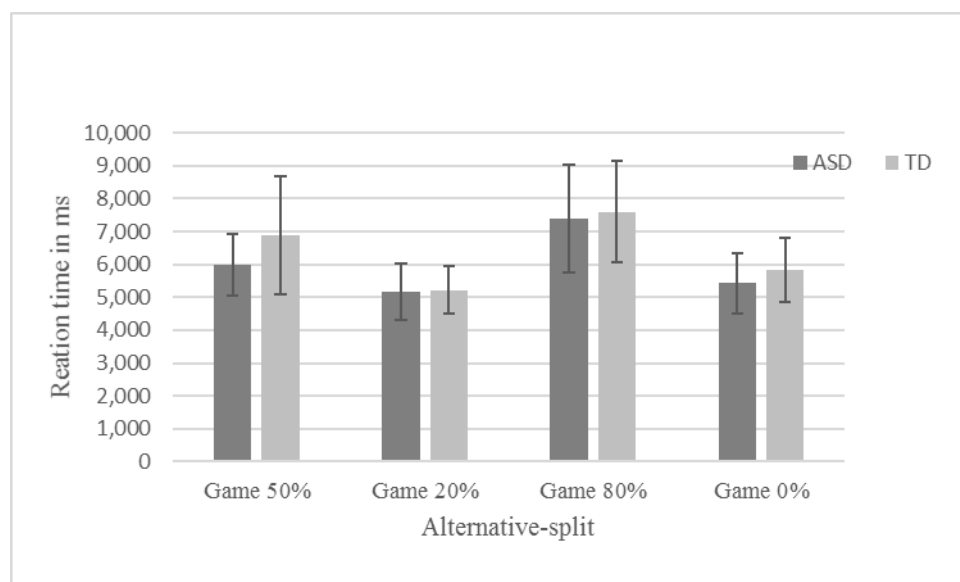


Figure 5.6 Decision time for acceptances and rejections combined across games and by group.

All in all, the pattern of results from the analysis between decision behaviour, fairness and decision -time shows that ASD and TD have similar reaction time when responding to the unfair offer in all four scenarios in the MiniUG.

The role of Theory of Mind

In this section the result of three measures are discussed. First, the results for the relation between ToM_{RMIE} and decision behaviour are presented in relation to proposer and responder behaviour. Then, we present the results for the Forecasting task, the measure we created to assess participants beliefs about responder's behaviour. These results are discussed in relation to the observed behaviour as proposers. And finally, following the analysis in previous chapters, results for the relation between decision behaviour and participants' ethics positions are presented.

ToM abilities and decision behaviour as proposer and responder

Simple correlations were examined to identify whether ToM_{RMIE} (RMIE: Baron-Cohen et al, 2001) our measure of theory of mind might correlate with participant's decisions as proposer and responder. As proposer, we tested for each game the relation between ToM abilities and the decision to offer the more egalitarian split in games 50% and 0%. Game 80% is particularly interesting since offering the less self-beneficial option may result in higher acceptance, therefore a relation with ToM_{RMIE} abilities was expected. Game 20% was excluded as in this game the two options are the same. As responder the relation between ToM abilities and the proportion of rejection of the fixed split in each game was tested.

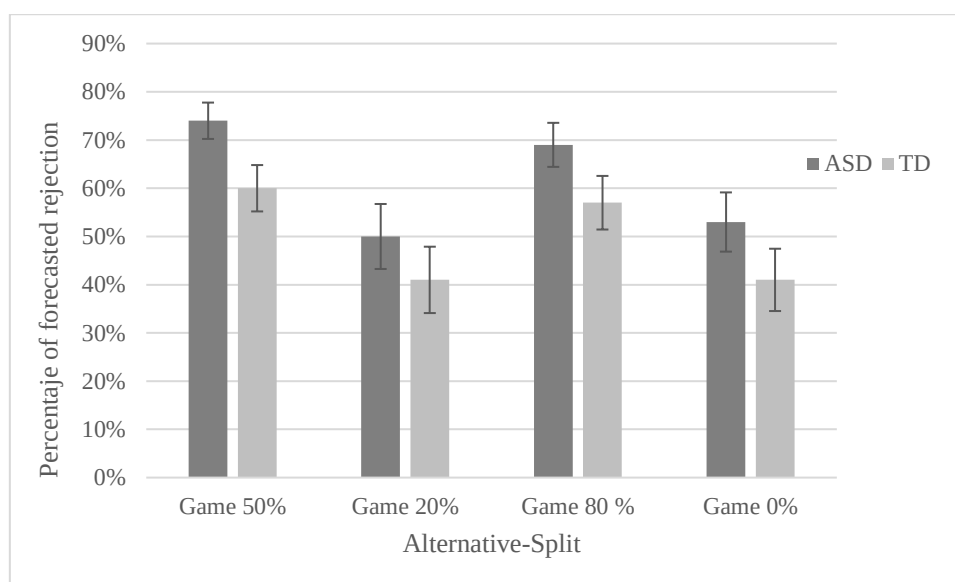
No significant correlations were observed between ToM and decision behaviour as proposer or responder, for all pairs $ps > 0.050$., this suggesting that other factors might have guided proposer's and responder's decisions in this MiniUG. Results for proposer and responder behaviour are reported in Table 5.4 which sets out the simple correlations (Pearson's r coefficients) between decision behaviour in each of the four games (game 50%; game 20%; game 80%; game 0%) as proposer and responder. Correlations are shown for both groups combined as well as for each group separately.

Table 5.4 Correlations for ToM, decision behaviour by group and game

		Game 50%			Game 20%			Game 80%			Game 0%		
		ASD	TD	Combined	ASD	TD	Combined	ASD	TD	Combined	ASD	TD	Combined
ToM	Proposer	-0.05	-0.08	0.06	NA	NA	NA	-0.03	0.06	0.03	0.14	0.20	0.16
	Responder	-0.16	-0.02	-0.09	-0.27	-0.16	-0.21	-0.21	0.09	-0.12	-0.21	-0.18	-0.15

Proposer decision, Forecasting

The above analyses suggest that, contrary to predictions, there were no associations between ToM as measured by the RMIE and acceptance/rejection rates in the mini UG. The forecasting condition provides a further opportunity to assess participant's beliefs about what might motivate responders. Although the question was *"How many people will accept this offer"*, results are presented in terms of rejections to keep consistency with the description of the results across conditions. Figure 5.7 presents the average of forecasted rejection rates of the fixed-split (80%: 20%) across games by group.

**Figure 5.7** Forecasted rejection rate of the fixed-split across games by group

A two-way analysis of variance (Mixed ANOVA) was used to examine the effect of the fairness of the alternative - split (game 50% vs. game 20% vs. game 80% vs. game 0%) and group (TDs vs. ASDs), which yielded a main effect of fairness, $F(3,159) = 26.30$, $p < 0.001$, $\eta^2 = 0.33$, which paralleled the pattern observed across levels of fairness in the responder condition above, with higher predicted rejections game 50% ($M = 0.67$, $SD = .23$) and game 80% ($M = 0.62$, $SD = 0.27$), compared to game 20% ($M = 0.45$, $SD = 0.35$) and game 0% ($M = 0.46$, $SD = 0.33$) – all relevant $ps < 0.005$. Of more interest, there was again no main effect of group $F(1,53) = 2.56$, $p = 0.11$, $\eta^2 = 0.046$ and no significant fairness x group interaction $F(3,159) = 0.16$, $p = 0.92$, $\eta^2 = 0.003$.

In addition, to the above analysis, it was also of interest to knowing the extent to which the predictions people make about other's behaviour were related to the decisions they made themselves as proposers. Simple correlations were examined to identify whether the proportions of times the fixed split was chosen in the proposer condition correlated with the forecasted rejection rates in the equivalent game in the forecasting condition. See all correlation in Table 5.5. Somewhat surprisingly, predicted rejection of the (80%: 20%) split was not correlated with the amount of times proposers choose this offer split, for Games 50% and Game 0% $ps > 0.050$. Thus, somewhat paradoxically, the absence of correlations indicates that, in the role of proposers, participants did not take into consideration the information they hold about responder's behaviour, which suggests that ToM may not play as much of a role in the MiniUG as the earlier study by Pelligra et al.,(2011) suggested. However, in Game 80%, predicted rejection correlated with the number of times proposer choose to offer the fixed split.

As seen in Table 5.5, although the result is significant for both groups together ($p = .018$), this was driven by the significance in the ASD group only ($p = .020$). Interestingly, the direction of the correlation indicates that the higher the predicted rejection rate of the fixed split

the more it is offered. In this game offering the alternative split (20%: 80%) would increase the possibilities of having the offer accepted since it will be beneficial to the responder.

Game 20% was again excluded as here the two splits represent the same pot distribution, instead a correlation was examined to identify whether actual rejection rate correlates with the forecasted rejection rate in this game, interestingly in none of the groups the correlations were significant, thus the lack of accuracy in the assumptions people made about others' rejection rate could lead to suggest that participants may not have taken into account other's beliefs.

Table 5.5 Bivariate Correlations between forecasted rejection rate and proposer decisions by game and group

	ASD	TD	Combined
Game 50%	0.22	-0.01	0.16
Game 20%*	-0.98	0.23	0.06
Game 80%	0.40	0.24	0.30
Game 0%	-0.22	0.06	-0.10

* Forecasted rejection was correlated with the actual rejection

5.3 Correlations / Predictors of Decisions MiniUG decisions

VIQ, E-S, BIS/BAS, EPQ: idealism /realism

Last, results for the relation between decision behaviour and participants' scores in VIQ, Difference between Empathising and Systemizing (E-S: Baron-Cohen, 2009); Behavioural Inhibition and approach scales (BIS/BAS: Carver & White, 1994); Ethics position questionnaire (EPQ idealism /realism: Forsyth, 1980) is presented. Table 5.6 shows, for each group (ASD and TD), the mean score for each of these measures. Statistical differences were found in the E-S measure, showing that in accordance with the original paper, ASDs have in overall higher systemizing scores than empathizing, hence the negative sign.

Table 5.6 Characteristics for autistic individuals (ASD) and Typically Development Individuals (TD) in VIQ, EPQ, E-S, BIS/BAS

	ASD (21m,6f)		TD (19m,9f)				
Measure	M (<i>SD</i>)		M(<i>SD</i>)		<i>t</i> (53)	<i>P</i>	Cohen's <i>d</i>
VIQ	108.04	27.44	108.50	22.24	0.67	0.94	0.01
EPQ _{Ideal}	67.45	17.29	64.50	13.82	0.57	0.57	0.18
EPQ _{Rel}	54.75	17.25	48.75	9.56	1.26	0.21	0.43
E-S	-10.64	19.08	15.47	14.97	5.24	< 0.001	1.52
BIS	11.52	4.09	13.73	5.53	1.58	0.11	0.45
BAS	27.56	7.10	26.13	5.55	0.77	0.44	0.22

Following the data analysis approach of previous chapters, simple correlations were examined to identify whether these measures might correlate with participant's decisions as proposer and responder. Results for both proposer and responder behaviour are reported in Table 5.6. As noted earlier G 20% is excluded from the analysis in proper behaviour since the two options available to the proposer are exactly the same. No significant correlations were observed in the role of proposer which suggest that other factors, not measured in our design, might have guided proposer's decisions.

Results for responder behaviour are reported in Table 5.7 which sets out the simple correlations (Pearson's *r* coefficients) between rejection rates of the unfair split in each of the four games (game 50%; game 20%; game 80%; game 0%), Verbal IQ, E-S-, BIS/BAS, EPQ idealism (EPQ_{Ideal}) and realism (EPQ_{Rel}). Correlations are shown for both groups combined as well as for each group separately and *r*-coefficients greater than 0.3 are highlighted in bold for ease of reference (See table footnote for significance level). To adjust for the multiple comparisons an alpha value of <0.001 (0.05/48 correlations per group) would need to be adopted as an appropriate significance level, hence none of the correlations is significant after applying Bonferroni corrections.

Table 5.7 Bivariate Correlations between individual differences in VIQ, EPQ, E-S, BIS/BAS and decision behaviour of the unfair split in each game.

		ASD				TD				Combined groups			
		G 50%	G 20%	G 80%	G 0%	G 50%	G 20%	G 80%	G 0%	G 50%	G 20%	G 80%	G 0%
VIQ	Proposer	0.08	NA	-0.05	-0.08	-0.07	NA	-0.08	0.08	0.04	NA	-0.06	0.05
	Responder	-.41*	-.47**	-.35*	-.39*	-0.03	-0.07	-0.10	-0.18	-0.24	-0.28	-0.25	-0.28
EPQ _{ideal}	Proposer	-0.18	NA	0.00	-0.24	-0.22	NA	-0.34	0.17	-0.17	NA	-0.09	-0.17
	Responder	.70**	.67**	.71**	.60**	-0.11	-0.38	-0.33	-0.39	0.41**	0.34*	0.48**	0.31*
EPQ _{rel}	Proposer	0.30	NA	0.16	-0.21	0.14	NA	-0.22	0.04	0.32	NA	0.04	-0.20
	Responder	0.23	0.29	0.07	.42*	-0.41	-0.24	-0.31	-0.30	0.08	0.21	0.02	0.25
E-S	Proposer	0.13	NA	0.00	-0.12	-0.06	NA	-0.25	0.08	-0.03	NA	0.03	-0.04
	Responder	0.07	0.32	0.12	0.34	-0.38	-.42*	-0.32	-0.38	-0.08	0.02	-0.06	0.09
BIS	Proposer	-0.04	NA	-0.04	0.10	0.11	NA	0.08	0.22	-0.02	NA	0.06	0.16
	Responder	0.07	-0.17	0.00	-0.26	0.07	-0.26	0.03	-0.20	0.07	-0.22	0.00	-0.20
BAS	Proposer	-0.19	NA	0.06	0.30	-0.08	NA	-0.36	0.12	-0.14	NA	-0.10	0.22
	Responder	0.18	0.25	0.24	0.19	0.19	-0.14	0.12	-0.10	0.18	0.11	0.20	0.07

*** $p < 0.001$; ** $p < 0.010$; * $p < 0.050$

Correlations observed here replicate the pattern of results for ASD in experiment 3, where VIQ and decision behaviour as responder showed a significant correlation, and also replicate the results in experiment 1b where responder behaviour was associated with the EPQ_{ideal} scale of the Ethics Position questionnaire (Forsyth, 1980). Similarly, the significant correlation observed for TDs in the role of responder in game 20% replicates the relation observed in experiment 1b (ARG) whereby rejection of the £(7:3) split was associated with the E-S scores. Noteworthy that Game 20% and the £(7:3) split represent a similar distribution of the pot, and since in Game 20% both choices available to the proposer were the same, this game is comparable to a standard UG.

5.4 Discussion

In the current study we address the question whether the relative importance of outcomes versus intentions differ between ASD and TD individuals during the decision making in the UG. We implemented a MiniUG, a version of the UG in which the options available to the proposer are restricted to only two choices on how to split the pot, and this information is

given to the responder. Responders were always present with the same unfair offer, along with the alternative split the proposer could have chosen. The alternative split varies in levels of fairness. In the current design, the fairness ratio was implemented as in (Falk et al., 2003; Sutter, 2007) but whereas they used the strategy method to increase the number of responses per participants, in the current study six MiniUG were implemented for the same purpose.

The experimental session was made of three tasks, with some other unrelated task in between, that are not reported here. First, participants acted as responders, next they did a forecasting test, and finally played in the role of proposers. When ToM data was not available, participants did the ToM_{REMIE} (Baron-Cohen et al., 2001) at the end of the session.

No major differences were found in decision behaviour between ASD and TD regarding their choices as proposer or responders. Against our prediction, that ASD would have responded with the same strategy across the four scenarios, we have found that both groups (ASD and TD) showed sensitivity to the alternative option when deciding whether to accept or reject an unfair (80:20) split. As proposers ASDs do not always choose the maximizing option.

As noted in the introduction, one reason for predicting differences between ASD and TD participants in this MiniUG relates to the notion that UG decisions are affected by ToM abilities therefore given the well-known ToM impairment in ASD would result in different decisions. Although the two populations significantly differ in their levels of ToM abilities as measured by ToM_{REMIE}, not association was observed between decision behaviour on the MiniUG and ToM abilities. Furthermore, the results of our forecasting measure showed that our participants accurately predicted other's rejection rate, however a null correlation between the results from the forecasting measure and proposer behaviour indicates that participants were not using this information when choosing an offer.

With our design we confirm previous finding in that people respond differently to level of unfairness in MiniUG with adults (Falk et al., 2003; Güney & Newell, 2013; Güroğlu et al., 2010) and with children (ASDs: Pelligra et al., 2015; TDs:Sutter, 2007), furthermore the rejection rate of the fixed split (44%) when the alternative offer was exactly the same, replicated the rejection rate for the standard UG (Camerer, 2003) suggesting that participants value fairness even if at the cost of their own benefit (Falk et al., 2003; Fehr & Schmidt, 1999). As proposers, participants choose fair games over the unfair options, yet this may not necessarily be the result of anticipating other's behaviour as it has usually been suggested.

From our design we cannot conclude whether the observed behaviour was the result of pure inequality aversion, or because proposers were trying to maximize and therefore strategically choose an offer unlikely to be rejected by the responder (Hardy-Vallée & Thagard, 2008). Anonymity has been suggested to promote unfairness (Camerer, 2003b) and given the structure of our design participants could have made less fair offers but this was not the case in the current study where 90% of the participants chose to offer the fair split in game 50%, and the most fair split in game 0%. In game 80%, participants choose to offer the split that favour the responders, yet this can be a strategic decision. Participants may anticipate that an unfair that favours the responder will be more readily accepted than an offer favouring the proposer. In addition, the observed behaviour can be added as evidence that our participants were aware of the realistic nature of the economical exchange.

On the other hand, the lack of involvement of ToM abilities, as measured by our ToM task, in MiniUG decision behaviour, but different rejection rate of the fixed split across the four fairness scenarios, indicates that these rejections were shaped by how fair the outcome was perceived in comparison with the outcome in the alternative split, and by ethical considerations in regard to norms, such as fairness considerations. The rejection rate was not significantly different between game 50%, in which the unfairness was against the responder,

and in game 80%, when the unfairness was against the proposer, suggesting that self-interested motives might drive the judgement of fairness when the alternative option heavily disadvantages the responder over the proposer. The rejection in game 20% suggests that pure inequality aversion plays a role in this game and supports previously reported findings of Falk et al., (2003) whilst questioning pure intention-based models (Dufwenberg & Kirchsteiger, 2004; Rabin, 1993). On the other hand, the rise in the rejection rate in game 80% compared to game 20% and the reduced rejection rate in game 0% suggest that levels of intentionality are involved in decision behaviour, or at least to some extent decisions are made with reference to the alternatives the proposer had available.

Turning to the results of the correlation analysis, the association between moral judgment and UG decisions is in line with the observations of Güroğlu et al., (2010) who reported that rejection of offers in game 20% and when participants accepted offers in game 50% and game 80% were associated with insula activation, a brain area involved in fairness judgments (Sanfey et al., 2003; Tabibnia et al., 2008) error signal associated with norm violation (Montague & Lohrenz, 2007) and norm compliance (Spitzer et al., 2007). In our study, and only for ASD group, there was an association between responder behaviour and EPQ_Idealism, which suggest that for these participants following social norms may be the guiding compass when judging fairness as responders in the MiniUG. The RT data showed that the ASD nominally took longer to reject than TDs. Although this no resulted in differences in rejection rate, it could be suggested that ASD participants were making comparison using an egalitarian fairness rule. However, in day to day social life where not all interactions are rule defined, this parsimonious judgement may not be possible and decisions become difficult (Luke et al., 2012). As for TD group we can only speculate that responders were taking an outcome-based approach and use a self-reference fairness heuristic as rule of thumb for making decisions. In the MiniUG the nature of the fixed-split and the possible outcome with the

alternative-split was fully known to decision makers, thus this information may have been sufficient to implement a fairness heuristic and not higher order mentalizing processing necessary.

The current study demonstrated that the presence of an alternative option modulates fairness judgments and enhanced tolerance towards unfair offers, thus suggesting that unfair proposals are more likely to be forbidden when alternatives are presented, even if not available to the responder.

6 GENERAL DISCUSSION

The starting point for this thesis was the observation that there is currently insufficient evidence to characterize social decision making in the autistic population. Although other relevant evidence consistently shows that multiple facets of social functioning are compromised in autism, scientists continue to debate whether these difficulties are present in all the domains of social cognition necessary to thrive in day to day life. This project focused on social decision making since this domain provides a window into the social world of ASD individuals because of the multiple intertwined processes involved, some of which represent strengths for autistic individuals (e.g. systemizing), while other processes represent difficulties (e.g., ToM, emotion processing).

The UG (Güth et al., 1982) was chosen to investigate social decision making in ASD in the current thesis to test the hypothesis that the strengths and weakness associated with the disorder would result in distinctive patterns of decision behaviour on this paradigm. The UG was considered to be an ideal paradigm for carefully examining social decision-making in ASD because it consistently elicits a pattern of economically irrational behaviour in the general population that is thought to be motivated by the interaction of a number of processes that are implicated in ASD, including theory of mind, emotion-related processes such as empathy and the tendency for ‘systemizing’. The UG allows for the exploration of the role of such factors both in terms of individual differences across participants as well as through experimental manipulations designed to moderate the influence of one or more of these factors on decision behaviour. To date, only a handful of studies have examined decision making on such game-theoretical decision tasks (See Table 1.1), with the evidence tentatively supporting differences

in behaviour in ASD that are related to factors such as ToM. However, the evidence remains scarce and this thesis represents a novel attempt to systematically explore UG behaviour across different experimental conditions in ASD.

On the whole the results across the four major experiments set out in this thesis suggest no substantial behavioural differences between ASD and control participants in UG behaviour, although experiments 2 and 3, suggested differences between the groups in relation to the cognitive processes each group recruited during decision making. As proposers in Experiment 1 (Chapter 2) and Experiment 4 (Chapter 5) ASD and TD participants similarly made fair offers whenever possible. It is noteworthy, that whereas in Experiment 1 there were no restrictions in the amount of money that the proposer could choose to offer, in Experiment 4 the proposer had limited choices given by the experimental design, yet both groups of participants, in both experiments made offers unlikely to be rejected and this was associated with a balanced profile of (E-S) and their behaviour as responders.

As responders, participants from both groups similarly accepted/rejected unfair offers. However, the decision-making process relied on different mechanisms with the ASD group mostly relying on VIQ and levels of moral and ethical principles as measured by the EPQ in Experiment 1 (Chapter 2), Experiment 2 (Chapter 3) and Experiment 4 (Chapter 5). On the other hand, decision behaviour in the TD group was associated with VIQ in Experiment 3 (Chapter 4) and (E-S) in Experiment 4 (Chapter 5). In Experiment 2 (Chapter 3) while TD participants differentiated intended (i.e., human) from not intended (i.e., computer generated) unfair offers, ASD did not make such a differentiation specifically on trials that represent the biggest conflict between fairness vs. self-interest considerations (£7:£3). In Experiment 3 (Chapter 4) although ToM mechanisms appeared to be recruited by ASD when making decision under time pressure, no relation between ToM and decision behaviour was observed in the TD group. Statistically, trends in the whole sample were driven by ASD since ToM only seem to

play a role in the decision behaviour of this group. In Experiment 3, in addition to ToM, cognitive reflection as measure by the CRT task predicted acceptances of unfair offers in both groups. Finally, in Experiment 4 (Chapter 5) the pattern of results in the no-alternative choice game, replicated that observed in Experiment 1 (Chapter 2).

In the discussion that follows, the results across the four experiments will be discussed in relation to some of the most common explanations that have been given for the consistent pattern of behaviour on the UG, which reliably contradicts the notion that decisions should be guided by an economically plausible maximizing principle (i.e., proposer should offer the minimum positive amount, and responders should accept any offer).

The evidence reported in this thesis suggests two potential accounts for participants' willingness to reject/accept an offer: (1) Participants are motivated to comply with reciprocal fairness, which implies that players hold certain beliefs about how other players should behave during the interaction. (2) Decisions are based on inequity aversion, whereby aversion to the unequal distribution of resources in its own right guides decision behaviour, with little influence of the context in which decisions are made.

In relation to the first option, a considerable amount of evidence suggests that reciprocity is fundamental to the maintenance of human society (Falk & Fischbacher, 2006; Fehr, Fischbacher, & Gächter, 2002; Gintis, 2000) and is encouraged in different ways in human culture (Gächter & Herrmann, 2009). Individuals can engage in reciprocity by responding to kindness with kindness (positive reciprocity) or responding to a negative action with a negative action (negative reciprocity). Either type of reciprocity implies that a decision maker infers (implicitly or explicitly) certain intentions to those they interact with and therefore it has been suggested that theory of mind abilities may be involved in guiding acceptances/rejections in the UG. To examine the role of theory of mind and the closely related

construct of empathising vis-à-vis systemising, relevant trait [ToM; EQ,SQ; E-S] measures were included across the experiments in this thesis. In addition, a second group of measures was included that assess traits that are more concerned with certain cognitive dispositions of an individual rather than their interpersonal skills [7i-CRT-;BIS/BAS;EPQ]. In the first group only, the E-S difference score was related to decision behaviour suggesting that rejection rate is closely related to a person tendency to think about the rules that govern systems. Associations between the 7i-CRT and EPQ in the second set of measures further corroborates this impression by suggesting that that participants were rather judging offers based in their views about social norms, i.e. inequity aversion and their own pre-disposition towards rewards, rather than showing empathy (EQ) or assigning intentions to the proposer [ToM]. These findings will be now discussed in more detail in relation to people's roles, both, as proposer and responder.

Proposer behaviour

In the role of proposer (Experiment 1, one-shot UG; Experiment 4, Mini-UG) no differences were observed between ASD and TDs. In line with most one-shot UG studies, the mode offer was (50:50) and in the Mini-UG participants chose the egalitarian split when it was an option, or they chose a split that was the least unfair out of two unfair options, confirming previous findings from laboratory experiments which suggest that egalitarian offers are the result of strategic thinking to get ultimatums accepted. In this respect, our results showed that egalitarian splits were more likely to be made by proposers who accepted an unfair split as responders, and by individuals who demonstrated greater differences in levels of empathizing and systemizing as measured by the (E-S;Baron-Cohen, 2009) in Experiment 1 (Chapter 2).

Higher scores on empathy, in relation to scores in systemizing, may have allowed participants to switch perspectives to anticipate the feelings of responders when facing an unfair offer, thus offering an egalitarian split as a strategy to avoid having an offer rejected

(Camerer & Thaler, 1995; Fehr & Schmidt, 1999; Kahneman, Knetsch, & Thaler, 1986; Ohmura & Yamagishi, 2005; Rabin, 1993; Thaler, 1988). Additionally, and interestingly, results from proposer behaviour in Experiment 4 (Chapter 5), showed that although a check for expected-acceptance rate indicates that participants accurately predicted acceptance rate for each offer, there was no correlation between this information and offers chosen, e.g. predicted acceptances of the unfair fixed split in game 80% where the alternative offer favours the responder, resulted in lower proposal rate, and instead the alternative offer was chosen. This suggesting that in the role of proposer individuals opt for strategic proposals.

Given that ASD and TD participants differed consistently across experiments in terms of their Empathizing-Systemising balance, it was surprising to find that offers did not differ between the groups. Specifically, the lower empathizing and greater systemizing pattern typically observed in the ASD groups, would – on the basis of the above argument – lead to the prediction of reduced fair offers in ASD vis-à-vis the comparison group. One possible reason for why this prediction was consistently not confirmed across experiments is that ASD participants may have engaged their systemizing not to derive an economically logical decision but to implement a social rule, which dictates egalitarian fairness. Such an interpretation would be in line with the observation that in some of the experiments reported in this thesis, decision behaviour in the ASD group tended to be more strongly related to scores on the EPQ (Forsyth, 1980) than in the comparison group. Thus, whilst TD participants may be making fair offers on the basis of emotion related processes related to empathy, ASD participants may be making egalitarian offers more on the basis of an adherence to social norms and rules (Greene et al. 2004)

Another possibility for the equivalent proposer behaviour between ASD and TD groups, despite consistent differences in empathizing/systemizing, is that any tendency that might exist for ASD participants to make fewer fair offers (as a result of differences in E-S)

are counteracted by a greater desire to avoid the negative consequences that might result from making an unfair offer. In Experiment 1 (Chapter 2) levels of BIS scores (Carver & White, 1994) were more strongly related to decision behaviour in the ASD than the TD group, with those who scored high on this measure more likely to make fair offers. Since high BIS scores are associated with avoidance of negative consequences (Berkman, Lieberman, & Gable, 2009), offering an egalitarian split may serve to maintain control over the interaction and avoid unpleasant rejections or to avoid the negative consequences and feelings that may be associated with the prospect of breaking a social rule or norm.

Responder Behaviour

Turning to the role of responder, across the four experiments rejection rates confirmed the standard finding that around 40% of adult players in western societies reject offers that are below 30% of the total pot; Experiment 1 (45%), experiment 2 (44%), experiment 3 (39%) experiment 4 (44%). In addition, patterns of rejection in games where the unfairness favours the proposer (an offer of £3 out of £10) were different to patterns of rejection when the unfairness favours the responder (Experiment 1, hypothetical UG and Experiment 4 Mini-UG) replicated finding suggesting that egalitarian fairness considerations are present in UG decisions (Brañas-Garza et al., 2014). Surprisingly, and contrary to our prediction, ASD and TD participants were very similar in terms of the overall levels of rejection of unfair offers, although the results suggest that there may be some differences with respect to the cognitive and psychological mechanisms underlying decision making between groups.

In the one-shot UG of Experiment 1 identical numbers of ASD and TD participants rejected the unfair (£7:£3) offer and responses to the hypothetical scenarios were also nearly identical. Moreover, accepters and rejecters within each group did not differ very substantially with respect to any of the individual difference's variables measured, with exception of the

EPQ idealism scale, which was significantly higher in TD accepters than ASD accepters, with no difference between groups in those who rejected.

However, within-group analysis showed that in the ASD group, EPQ idealism scores were higher in those who rejected compared to those who accepted unfair offers, whereas no differences in the scores were observed between accepters and rejecters in the TD group. The EPQ (Forsyth, 1980) measures how likely a person is to embrace the universality of moral and ethical principles. Individuals who score high in EPQ Idealism consider ethical behaviour is only ethical if the consequences are exclusively good and they believe ethical behaviour can always be achieved by strictly following universal moral rules, for example, people who hold a strong belief about egalitarian fairness will reject an unfair offer regardless of the motives held by the proposer. On the other hand, high EPQ Relativism suggests individuals have a tendency to reject the notion of universal moral principles thus preferring personal and situational analysis of behaviour. These individuals usually assume that ethical decisions are made by weighing good consequences against bad consequences. Group differences in the scores for those who accept the unfair split, with higher scores in the TD vs. ASD, but not group differences between those who reject, may indicate that UG acceptances involve some aspects of moral judgment whereas rejection may be more automatic.

Interestingly, within-group analysis showed differences between accepters and rejecters in the ASD group only, with higher EPQ idealism scores for those who reject compared to those who accept. No such differences were observed in the TD group which may suggest that ASD go through similar judgments processing, i.e. moral, before deciding whether to accept or reject. Although it is important to interpret this result with caution due to the multiple comparisons that were carried out in this first experiment, group differences in the role of EPQ idealism were further supported by the results in Experiment 2 (Chapter 3), where rejection rates of unfair offers correlated with VIQ and EPQ Idealism in ASD but not the TD

group; and in Experiment 4 (Chapter 5) where rejection of the unfair split correlated negatively with VIQ and positively with EPQ idealism only in the ASD group.

These correlations may indicate that ASD engaged in some type of moral reasoning when making decisions over unfair offers, whereas TD may be guided by empathy considerations which is supported by the results in Experiment 2 (Chapter 3) where rejection of the unfair offers was associated with scores in the (E-S) measure, and in Experiment 4 (Chapter 5) where (E-S) was positively correlated with rejection of the fixed split in Game 20% which represent a similar decision scenario as in the standard One Shot UG implemented in Experiment 1 (Chapter 2).

In addition to differences between groups with respect to the role of idealistic moral rules, the results across several of the experiments also indicated that theory of mind processes may be drawn upon differently in UG decision scenarios between ASD and TD participants. In Experiment 2 (Chapter 3), the role of ToM was probed by implementing a proposer manipulation whereby UG offers were either presented as coming from a human or a computer proposer. Previous studies (e.g., van t'Wout et al., 2006) had shown that participants generally are more willing to accept unfair offers from computers rather than humans, presumably because unfair intentions would be attributed only to human proposers. The results of Experiment 2 replicated this effect but also showed that ASD participants were, as expected, less sensitive to the proposer manipulation than TD participants for offers that were marginally unfair. That is, whilst TD participants accepted £3-£7 offers significantly more often when coming from a computer than a human proposer, ASD participants accepted these offers equally often from both types of proposers. Although rejection rates did not correlate with ToM abilities as measured by the RMIE task (Baron-Cohen et al., 1997) in this study, this pattern of results is generally in line with the suggestion that individuals with ASD may not be sensitive to social intentionality carried by the offers, in this case unfair offers (Chiu et al., 2008b).

Differences in the role of ToM between groups were further supported by the results of Experiment 3 (Chapter 4), in which participants needed to make decisions either under time limits or without time constraints, thus manipulating the extent to which deliberate vs. more intuitive processes could be engaged to support the decision-making process. ToM predicted rejection behaviour in the ASD group in both time and no time pressure conditions whereas no such a relation was seen in the TD group. This trend is particularly interesting for two reasons. On the one hand it adds evidence to previous but not consistent suggestion that theory of mind plays a role on UG decision making (Schug et al., 2016), we will come back to this in the next paragraphs. On the other hand, the fact that ToM abilities turned out to be activated under time pressure condition, and in the untimed condition contribute evidence for understanding developmental aspects and use of ToM.

In Experiment 3 (Chapter 4) although there was not an obvious reason for participants to expect unfair offers, the certainty of having to make decisions under time pressure may have increased alternativeness in the ASD group, and this may have been a strong enough contextual factor to trigger ToM mechanisms. This argument is in line with existing evidence suggesting that at least some aspects of the mentalizing network may be intact in autistic adults (Roeyers & Demurie, 2010) Furthermore, as suggested by Bowler, (1992) and Frith, (2004) “ displaying an explicit theory of mind does not necessarily imply an intuitive mentalizing ability” (p. 678) and this explicit theory of mind may be affected by factors such motivation, sensitivity or the nature of the task, hence the lack of such a relation in Experiment 1 (Chapter 2) and Experiment 2 (Chapter 3) and Experiment 4 (Chapter 4), where rejection behaviour was correlated with both VIQ and EPQ Idealism scale in the ASD group only. Furthermore, since performance in VIQ is influenced by background, education, cultural experiences and knowledge learnt from the environment, it is not surprising that this measure and decision behaviour are associated in the ASD group only, thus stressing the view that ASD decision behaviour depends more in

information processing, e.g. Social Norms than in reciprocal motivations. In addition, the positive correlation between VIQ and ToM in the ASD group but not in the TD group, confirm previous evidence suggesting that the interaction between ToM and other cognitive functions in ASDs continues to develop with learning (Verbrugge & Mol, 2008), experience (Dumontheil et al., 2010) and is shaped by culture (Heyes & Frith, 2014).

Whether ToM mechanisms are thought to be fundamental to UG decisions in the standard population is still an unsettled debate. Most of the evidence for ToM comes from studies manipulating the type of proposer and asking individuals to respond to offers made by human vs. offers randomly generated by coin toss or computer proposers, as in our Experiment 2 (Chapter 3); or manipulating the offer options available to the proposer and making these options clear to the responder in efforts to aid responders to judge the intentions of the proposer, as in Experiment 4 (Chapter 5). Other evidence also stems from brain imaging research which indicates that ToM regions are activated during UG and other similar decision making paradigms, although this evidence is less directly relevant to the work presented in this thesis (for a review; Gabay et al., 2014).

In addition to implementing such manipulations, the current study also examined the role of ToM in decision behaviour by correlating performance on an adult ToM task with decision behaviour on the UG, similar to how previous studies have compared decision behaviours on the UG between children who either passed or failed ToM tests (e.g., Takagishi et al., 2010) and our result add to the evidence that although ToM may play a role in some social scenarios, it is not always the case (Castelli, Massaro, Bicchieri, et al., 2014; Schug et al., 2016). The fact that the different manipulations and measures employed in this thesis to probe the role of Theory of Mind did not yield a consistent picture, has several implications. First, it may suggest that the different experimental manipulations are not all equally effective in manipulating the role of ToM. For instance, different experimental manipulations (proposer

manipulation, time pressure, MiniUG), may not all manipulate ToM involvement in the same way. Different paradigms might differ with respect to whether people might think explicitly (e.g., MiniUG) vs. more implicitly (e.g., One Shot UG) about the intentions and motives of the proposer. When the stimuli are so obvious and salient as a social rule, individuals do not need to engage ToM abilities to respond to the interaction, and instead rely in that social rule. When these rules are so imbedded in the beliefs system individuals use them almost in automatic, and this may have led researchers to interpret an automatic ToM usage.

Fairness judgments require the assessment of the responder's internal norm of fairness and also require that the responder creates a model of the proposer, therefore it is expected that some aspect of theory of mind gets involved. However, it may be that those very specific aspects were not fully captured by our ToM measure, for one of two reasons: either because these aspects have become automatized with experience and a more fine-grained ToM measure is required e.g. (Faux Pas; Baron-Cohen et al., 1999), a test which measures vicarious embarrassment as a result of bypassing a social rule; or because mentalizing abilities may get overridden by other higher cognitive processes, hence the relation between ToM and rejection behaviour of fair and unfair offer under time pressure and untimed conditions in the ASD group in Study 3 (time pressure manipulation). Taken together, the results across the experiments suggest that ToM play a role in UG decisions but that this role is highly dependent on the specific circumstances under which decisions are to be taken.

In addition, our prediction that a diminished ToM in the ASD group would lead to higher acceptances of unfair offers was not confirmed by our results. Correlations and regression analysis in Experiment 3 (Chapter 4) showed that low level of ToM predicted rejection rate when decisions are made with no time pressure. These finding challenge the restricted view that about rationality have been used in UG research in that acceptances are for the most the outcome of self-regarding motives. Instead our data brings about the idea that

rationality would be better associated with intelligence in a wider sense and interpreted as having the ability to go beyond the given information (Bruner, 1973) and to be able to switch perspectives and strategies when responding to social stimuli, for instance when choosing between competing options as is the case of the responder in the UG.

The result from our studies suggest that processes other than ToM (e.g., cognitive control and inhibition) may play more or less of a role in the different paradigms thus potentially overshadowing an involvement of ToM. The logistic regression model in Experiment 1 (Chapter 2) gives a subtle indication that BIS, our measure of behavioural inhibition bias, predicts rejection of unfair offer in One-shot UG. Future studies should continue exploring the role of ToM in social-decision making by using a combination of ToM measures and manipulations in iterated UG with the same proposer to try and tease apart some of these alternative possibilities.

In addition to the role of ToM, the evidence presented in this thesis also sheds some light on the role of intuitive vs. more deliberative processes on decision behaviour in the UG and of potential group differences in this respect between ASD vs. TD participants. Negative reciprocity theories suggest that in the presence of unfair offers, negative feelings lead individuals to reject (Halali et al., 2014; Koenigs & Tranel, 2007) and dual theories suggest that such emotional processes operate at a relatively automatic and subconscious level and that they may be overcome by deliberative processes that would lead to acceptance (Sanfey & Chang, 2008). The consistent correlation between VIQ and decision behaviour in the ASD group lends some additional support to the notion that certain decisions are deliberate, i.e., autistic individuals rely more heavily on their cognitive resources (Brosnan et al., 2016), in particular verbal reasoning skills, to deliberate about the choices they make, thus the current results add evidence to the ongoing debate within dual process theories.

Whereas some argue that UG decisions result from exerting control over an automatic desire to punish unfair behaviour, the alternative view suggests that UG decisions are the result of exerting control (Calvillo et al., 2015; Sanfey & Chang, 2008) over the desire to accept an unfair offer out of greediness and without taking into consideration other's preferences. The debate between these two views has been widely explored by dual theories of cognition suggesting that whereas the former results in acceptances once the individual overcome the impulse to act out of reciprocal fairness, i.e. punish (Knoch et al., 2010; Knoch et al., 2006), the latter suggest that overcoming the impulse to judge the split by its face value, leads the responder to take into consideration the context and intentionality of others ending in rejection (Sanfey et al., 2003; Tabibnia, Satpute, & Lieberman, 2008b). Our results are more consistent with the view that exerting control over the impulse to reject leads individuals to accept unfair offers in one-shot UG. For example, the results of Experiment 3 (Chapter 4) show that, under time pressure, individuals appear to be intuitively biased to reject, whilst acceptances are more likely to increase when there are no constraints on decision behaviour. Moreover, scores on the CRT in this experiment indicated that participants who have a greater tendency to engage in deliberative vs. more impulsive reasoning to solve problems, were more likely to accept than reject unfair offers, further suggesting that the rejection of unfair offers is a more intuitive and automatic response.

Interestingly, when examining the associations between the CRT and rejection rates separately in ASD and TD participants, the results indicated that low performance in the CRT predicted rejection of unfair offers in both time conditions (time pressure & untimed) in the ASD group, whereas in the TD group this relation was only significant in the TP condition. Since in the UG there are no right or wrong answers per se, the CRT correlation may indicate that participants who have a greater tendency for deliberative thinking may be more sensitive to cues that indicate that different perspectives/alternatives can be considered as an explanation

for a certain situation. In the context of the UG, for instance, this may lead to a deeper consideration of the intentions and motives behind an unfair offer, and how that compares to social norms and expectations, rather than to jump to decisions based on the value on an offer.

In this context it is interesting to note that ToM performance was also correlated with acceptance rates in this experiment. Specifically, high scores in ToM predicted acceptances of unfair offers. In relation to the points made above, it is also interesting to recall that the findings set out in Experiment 1 (Chapter 2) are in line with these findings. Rejecters but not accepters engaged in moral judgements and this is more specific for ASD, which was furthered by results in Experiment 4 (Chapter 5). Similarly, results from Experiment 2 (Chapter 3), did not replicate earlier findings by van't Wout et al., (2006) in suggesting that emotion-related somatic markers play a significant role in guiding decision behaviour in the UG. The assumption that such markers would play an important role stem from the perspective mentioned above that rejections are motivated by relatively automatic emotion related processes that are triggered by an aversion to unfairness or inequity.

Combining the above, with the results of Experiment 3 (Chapter 4), where rejection was related to VIQ, a measure of acquired knowledge, verbal reasoning, and attention to verbal materials, and the EPQ idealism, a scale that measures the extent to which an individual accepts or rejects universal moral rules, it may be that decision-behaviour is the result of judging the face value of the offer in reference to expected egalitarian fairness, an acquired cultural norm, but not necessarily by taking into consideration the proposer's motives. As shown by Dufwenberg & Kirchsteiger (2004) and Rabin (1993) other regarding preferences are not exclusive to reciprocal fairness. Preferences such as kinship and altruism, or inequity aversion and egalitarian fairness have been shown to lead the individual to take into account other's payoff and wellbeing during decision making. The current research offers support to previous

theories suggesting that egalitarian-fairness considerations underlie decision behaviour in one-shot interactions (Bolton & Ockenfels, 2000; Fehr & Schmidt, 1999).

Broadly speaking, the results from our research extend the evidence on ASD's social behaviour. Although a combination of cognitive processes makes it possible for ASD to reach similar decision as TD in the UG, the decision paths followed by ASD are believed to be cumbersome and time consuming, thus lack of the necessary flexibility to navigate the social world and its uncertainty. Unlike in day-today interactions, in the UG uncertainty is highly reduced by the fact that from the beginning of the interaction players know the consequences of their decisions and this may have facilitated ASD performance in the task by continuously relying in moral and ethical rules.

There is evidence (Baez et al., 2012; Heyes & Frith, 2014) suggesting that during social interaction adults with ASD can use social abstract rules, however since autistic adults do not automatically think about what others think of them (Cage et al., 2013), the use of these social rules cannot be directly interpreted as reciprocity as their decision behaviour may only represent adherence to the social norm (Perugini et al., 2003). Being good at following rules (Levin et al., 2015; Shulman et al., 2012; Sterponi, 2004) but having poor intuitive thinking can make ASD less prompt to endorse objectionable social behaviour but less accurate at identifying when other's fail to endorse rules, thus make ASD more exposed to be taken advantage of (Hillier et al., 2007; Levin et al., 2015; Wilczynski, Trammell & Clarke, 2013)

Across the four experimental conditions, whereas the pattern of correlations differ in TDs, the ASD group show a similar pattern of correlations, this suggesting that ASD participants may be less flexible in shifting between intuitive vs. deliberative strategies. Our result is in line with previous research by Brosnan, Lewton, & Ashwin (2016) who reported

that ASD is characterized by a consistent bias towards deliberative reasoning, and by Levin et al., (2015) that compared to TDs, ASD group showed less engagement in intuitive thinking.

Broader implications

Beyond the implications for decision behaviour on game theoretical scenarios such as the UG, the current observations also have implications for the social-cognitive characteristics of ASD and for theories concerning social-economic decision making.

In relation to ASD, the current findings are relevant to understanding that although the condition does not seem to hinder behavioural responses and these participants' decision-outcomes are similar to control TDs, the results from these four experiments showed that their cognitive system operate differently and probably more loaded. For instance, although ASD participants score lower than TD on the ToM task, their scores did not result in overall different rejection rate. However, in real life, bypassing the intentionality of others and their agency can result in significant difficulties in aspects that softly but consistent shape social exchange, for example, it can hinder tolerance attitudes towards the mistakes of others, diminish the effect of persuasion and the assertiveness to respond to or to produce persuasive acts; or delay the evolution of trust so necessary for the development of stable relations and friendship.

In terms of models of economic decision making, the current studies show how relatively difficult it is to identify and tease apart the various factors that contribute to seemingly 'irrational' decision behaviour. The terminology used in the field to describe and define behaviours, could help to make steady progress in identifying decision making factors. "Rationality" is by far one of the terms that seems to have a biased connotation in the literature. Rejecting an unfair offer, is frequently treated as an irrational decision or as a mechanism to re-establish fairness. On the other hand, acceptances are mostly associated with selfish behaviour. However, evidence has shown that decision makers reject unfair split as a way to

defend the imposition of an inferior status (Yamagishi et al., 2012), hence not all rejections are prosocial, and neither are all acceptances selfish. Accepting an unfair offer may have more prosocial motives than it has been considered (e.g. gratitude and loyalty, Henrich et al., 2005). More recently, the evidence given by Nguyen et al., (2011) who investigated the effect of cognitive and personality traits in UG showed that personality variables and specifically the tendency to trust predicted UG acceptances. Individuals who accepted unfair offers reported to be trusting of others, agreeable and prosocial, less prompt to perceive hostile attitudes and less concerned with the unfairness of the offers.

Most UG studies have been set up and behavioural result interpreted assuming players behave as if independent from a societal group, however a shift in this initial assumption to assume players recognize themselves as part of a group, gives rise to an alternative interpretation of acceptances. Accepting an unfair offer may not benefit the responder per se, but both players (proposer- responder), thus acceptances can be thought of as being prosocial, since the benefit of the interaction is distributed between the dyad proposer- responder.

More broadly, this frame, i.e. looking proposers and responder as a dyad, instead of two individuals, has implication for behavioural economics implementations. Targeting an intervention for individuals who consider themselves part of a group posit different demands than when individuals are considered independent individuals, thus in competition for resources. The dynamics of the XXI century may indeed benefit from social structures that instead of promoting donation and accumulation of resources triggers sharing and given attitudes to one and another as part of a society.

Limitations and Future directions

Before drawing this thesis to a close, it is important also to acknowledge some potential limitations and the implications of these for future research. Among the most difficult issues to

deal with in autism research, is the heterogeneity of the clinical phenotype. The experiments reported in the current thesis, focused exclusively on autistic participants who were adults and who had no (or very limited) language and/or intellectual impairments. Around 45% of autistic individuals, however, are estimated to have significant language and intellectual impairments (Baird et al., 2006), and it is unclear to what extent the findings presented here would be representative of this wider population. Similarly, it is unclear to what extent the findings would hold true for younger participants such as those studied in the experiments by Hill et al., (2006). Whilst it was useful to maintain a focus on adult participants across the experiments presented in the current thesis, to make it possible to compare results across these experiments, it is clearly also necessary for future studies to extend this work to younger participant groups and participants with co-occurring language and/or intellectual impairments. The findings from Hill et al., (2006) and the evidence in the current thesis concerning correlations between decision performance and IQ, indicate that systematic examination of UG behaviour across development and across the full range of intellectual abilities, will be critical for developing a comprehensive picture of social –decision making in ASD.

Another aspect to be considered as a possible limitation is the experience, with the UG task, gained by some participants who took part in more than one experiment. Across all experiments a total of 262 participants took place of which 29% took part in one, 35% in 2, 19% in 3 and 17% in all four experiments. It is difficult to formally take this participant overlap into account in the analysis for any particular experiment as exclusion of anyone who took part in more than one experiment would reduce sample sizes significantly and any significant group differences that did emerge would be set against the lack of group differences in a larger sample, making the interpretation difficult. Therefore, it is unclear to what extent experience with the paradigm may have diluted the results in some experiments. However, it is important to note that with the exception of the first experiment, all subsequent experiments involved

multiple trials and the principle phenomenon of interest (the irrational rejection of unfair offers) was stable and robust across experiments.

One more potential limitation of the work presented in this thesis, is the exclusive focus on the UG as an experimental paradigm to represent the complexity of social-decision making. Whilst focusing on this paradigm made it possible to implement a series of manipulations relatively systematically across experiments, it also meant that only a relatively narrow perspective could be gained on social decision-making. Although the experiments in this thesis included multitrial games, adding the interaction with the same partner would make it possible to examine leaning effects but also to explore reputation building as a competitive motive for rejection in the UG. Testing the concept of reputation building in the ASD population during socio economic exchanges is likely to provide evidence for the understanding of the social motivation difficulties in ASDs. Furthermore, the combination of a set of games during a testing session may contribute to ecological validity of the study by simulating the dynamic of real-life decision scenarios, for instance moving from a UG to a dictator. In addition, a continuation of this research project may benefit from including additional features to enhance the real nature of the interaction, for instance having the partner-player displayed in a video in real time; or by running group testing sessions.

Along with behavioural measures, the introduction of qualitative measures could help to understand the motives behind decision making and making the shift from analysing outcomes per se will extend the evidence on how individual differences and cultural knowledge determine decision behaviour.

Final Thoughts

This research project aimed to better understand how the decisions of others may affect us and how our decisions affect others, an area commonly known as social decision making.

Results from the series of UGs presented in this thesis nicely replicate previous findings in showing that individuals consistently decline unfair monetary offers from others despite forgoing personal gains. The experiments also extended the evidence concerning the roles of certain social-cognitive processes (ToM, moral judgment and the balance of systemizing vs. empathising) and less social-cognitive processes (cognitive reflection, behavioural inhibition vs. activation and Verbal IQ) in decision behaviour. Although questions remain to be addressed about the role of these processes and factors, the evidence from analysis of correlations within groups and comparisons between groups (ASD vs. TD) suggest that, in both groups, rejection in the UG are motivated by societal rules of inequity aversion, yet compared to TDs, autistic individuals engage different and less flexible cognitive mechanism to make decision that can affect them but at the same affect others. Knowing the factors involved in judgment and decision making in social scenarios could help us to identify our own cognitive bias and to recognize them when interacting with others, ideally aiming to promote wellbeing among those with whom we interact.

APPENDIX

Appendix A: Cognitive Reflection Task as used in the current research project with both type of answers (7i-CRT Toplak et al., 2014).

(1) A bat and a ball cost \$1.10 in total. The bat costs a dollar more than the ball. How much does the ball cost?	_____ cents
(2) If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?	minutes _____
(3) In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake?	_____ days
(4) If John can drink one barrel of water in 6 days, and Mary can drink one barrel of water in 12 days, how long would it take them to drink one barrel of water together?	_____ days
(5) Jerry received both the 15th highest and the 15th lowest mark in the class. How many students are in the class?	_____ students
(6) A man buys a pig for \$60, sells it for \$70, buys it back for \$80, and sells it finally for \$90. How much has he made?	_____ dollars
(7) Simon decided to invest \$8,000 in the stock market one day early in 2008. Six months after he invested, on July 17, the stocks he had purchased were down 50%. Fortunately for Simon, from July 17 to October 17, the stocks he had purchased went up 75% At this point, Simon has: a. broken even in the stock market b. is ahead of where he began c. has lost money	

Correct (incorrect answer)

1. Correct answer 5 cents; intuitive answer 10 cents
2. Correct answer 5 minutes; intuitive answer 100 minutes
3. Correct answer 47 days; intuitive answer 24 days
4. Correct answer 4 days; intuitive answer 9
5. Correct answer 29 students; intuitive answer 30
6. Correct answer \$20; intuitive answer \$10
7. Correct answer c, because the value at this point is \$7,000; intuitive response b

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